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REPORT OF THE CHIEF OF THE DIVISION OF SAFETY

FOR THE

FISCAL YEAR 1914

WITH PARTICULAR
REFERENCE TO

INVESTIGATION OF SAFETY DEVICES AND AN EXPERIMENTAL TEST OF THE GRAY-THURBER AUTOMATIC TRAIN CONTROL SYSTEM

AS PROVIDED BY THE URGENT DEFICIENCY ACT
(PUBLIC NO. 32) OF OCTOBER 22, 1913

Submitted by the Chairman of the Interstate Commerce Commission

January 11, 1915.—Referred to the Committee on Interstate and Foreign Commerce and ordered to be printed, with illustrations

WASHINGTON
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CONTENTS.

Page.
Report of the Chief of the Division of Safety to the Interstate Commerce Commission 5

Extracts from the Twenty-eighth Annual Report of the Interstate Commerce Commission pertaining to the work of the Division of Safety:

Safety appliances 33
  Judicial interpretation of the safety-appliance acts 34
Ash-pan act 36
Hours-of-service act 36
  Judicial interpretation of the hours-of-service act 37
Investigation of accidents 40
Investigation of safety devices 43
Gray-Thurber automatic stop 45

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LETTER OF SUBMITTAL.

Interstate Commerce Commission,
Offices of James S. Harlan, Chairman,
Washington, January 9, 1915.

To the Senate and House of Representatives:

The Interstate Commerce Commission has the honor to submit herewith the report of its Chief of the Division of Safety for the fiscal year ending June 30, 1914, calling particular attention to that part of the report relating to investigation of safety devices under the provisions of the urgent deficiencies act (Public. No. 32), approved October 22, 1913, which appears on pages 9 to 15, inclusive.

There is also submitted a typewritten copy of the report of the Commission's Chief of the Division of Safety concerning a test of the Gray-Thurber automatic train-control system, which was conducted by the commission's experts from April 13 to July 14, 1914.

Respectfully submitted.

James S. Harlan,
Chairman.

REPORT OF THE CHIEF OF THE DIVISION OF SAFETY TO THE INTERSTATE COMMERCE COMMISSION.

WASHINGTON, *October 1, 1914.*

To the Commission:

I have the honor to submit herewith a series of statistical tables showing a substantial increase in the number of cars inspected during the past fiscal year, as well as an appreciable reduction in the number of defects reported, as compared with preceding fiscal years.

From Table No. 1 it will be noted that 790,822 freight cars, 26,746 passenger cars, and 32,761 locomotives were inspected, of which 45,862 freight cars (5.79 per cent), 280 passenger cars (1.04 per cent), and 1,634 locomotives (4.98 per cent) were found with safety appliances either missing or defective. These percentages are exceptionally low, especially in view of the fact that, in addition to maintaining appliances in operative condition, carriers have been charged with the duty of standardizing their old equipment to meet the requirements of the Commission's order of March 13, 1911.

The summary at the end of Table No. 1 shows the average number of defects per 1,000 cars inspected, as to each classification, for the total number of cars inspected on all roads on which inspections were made. It is to be hoped that the designated carriers having an individual average, as indicated by Table No. 2, greater than this general average, will adopt such measures as will improve the situation on their roads.

Table No. 2 presents all roads upon which 500 or more cars were inspected during the fiscal year, the total number of defects reported as to each of the 16 classes, the grand total of defects reported, the total number of cars inspected, and the total number found to be defective.

Table No. 3 is based upon the terminal or standing tests of air brakes and shows the number of trains tested, the number of cars in those trains, the number equipped, and the number not equipped with air brakes, the number having brakes cut out, the number of brakes that did and the number of brakes that did not operate upon a service application of the air, the percentage of operative brakes, and the number of cars on which the air-brake piston travel was in excess of 9 inches. These data emphasize the importance of standing tests as a means of ascertaining the braking power of a given train.

Table No. 4, comparing statistical summaries for the past five fiscal years, illustrates the varying success attained by individual carriers in the maintenance of freight equipment.

Table No. 5 illustrates the results of prosecutions under the safety-appliance, hours-of-service, and ash-pan acts, as exhibited by the penalties collected from the various carriers for their respective violations of the statutes named, prior to November 1, 1914.

The decrease in the number of reported defects in couplers and uncoupling mechanisms is believed to be due to more diligent inspection, as well as to improvement in design of these appliances, which has been brought about by the efforts of the Master Car Builders' Association to develop a standard coupler, combining the maximum of efficiency with the minimum of detail in construction. The use of such a coupler will minimize the number of accidents resulting from defective appliances, in addition to reducing the cost of maintenance and repair of couplers and parts.

It is to be noted that nearly 50 per cent of the defects reported under the classification "uncoupling mechanism" have consisted in broken uncoupling chains, while more than an additional 10 per cent of such defects have resulted from uncoupling chains becoming kinked in coupler heads. Defects of this character could be entirely eliminated by the use of uncoupling devices in which the chain is not used, with the result that the personal injuries due to defective uncoupling mechanism would be materially diminished and the most prolific cause for prosecutions under the safety-appliance acts would be removed.

The period within which the carriers are to have rendered all cars in service on July 1, 1911, conformable to the standards prescribed will expire on July 1, 1916. From information furnished by the Commission's inspectors, it is evident that many of the carriers have not given these requirements sufficient attention. The number of freight cars already equipped is small as compared with the number to be equipped, and only the exercise of great diligence will enable some of the roads to bring their equipment up to the required standard within the time prescribed by the Commission's order.

Delayed observance of the requirements of this order will increase the difficulties of interchange, and result in a situation similar to that which existed during the period of transition from the link-and-pin to the automatic coupler. Carriers that shall have complied with the requirements of the order will, after July 1, 1916, obviously be in better position properly to meet their operating problems than those carriers who have failed to bring their equipment up to the required standard. Such carriers will not only be able to handle traffic more expeditiously than their derelict connections, but, being charged with the alternative of equipping foreign cars after receipt and before movement on their lines, will naturally refuse to accept cars that are not standard or permit the movement of such cars on their lines. The recommendation that all carriers be required to submit to the Commission quarterly or semiannual reports of their progress in the standardization of equipment is respectfully renewed.

The question of receiving and delivering defective equipment in interchange, and of hauling such equipment for the purpose of repair, has been somewhat clarified by recent court decisions construing the proviso in section 4 of the act of 1910. The trend of these decisions is to the effect that a car defective as to safety appliances may not lawfully be hauled by a carrier even for the purpose of repair unless (1) it was properly equipped at the inception of its journey, (2) became defective while in use by such carrier on its line of railway, and (3) has been discovered to be defective, when it may be hauled to the nearest available point where it can be repaired, provided (*a*) such movement is necessary for the purpose of making such repairs, and (*b*) that such repairs can not be made except at such repair point.

It is anticipated that as soon as the significance of this proviso is appreciated by the carriers the situation with respect to interchange will be improved. In this connection it is suggested that a lack of familiarity with the standards on the part of interchange inspectors and repairmen will cause many delays in interchange which may be avoided by proper education of employees. It is necessary to the quick dispatch of traffic that standard equipment shall be recognized as such, and that equipment not standard shall be promptly rejected or repaired. The importance of carriers requiring responsible employees at points of interchange to have a working knowledge of the safety-appliance acts, and a comprehensive understanding of the various orders of the Commission supplemental thereto, can not be too strongly emphasized.

The handling of chained-up cars in revenue trains or in connection with cars commercially used is somewhat less prevalent than heretofore, but occasional instances are still reported for prosecution. The law is plain in prohibiting the hauling of cars by means of chains instead of drawbars unless such cars, when so hauled, are not in revenue trains or in association with cars commercially used, and are hauled for the purpose of repair; and then such cars may be moved only to the nearest available point where requisite repairs can be made.

The indiscriminate handling of logging cars having drawbars of various heights, in connection with other equipment, has been the subject of numerous complaints, some of which, upon investigation, have been made the basis of prosecution. The proviso in section 6 of the act of 1893, as amended April 1, 1896, prescribes in definite terms the circumstances under which logging equipment lawfully may be used, and there is no justification for any violation of the law in this respect.

The maintenance of efficient hand brakes as well as of power brakes is prerequisite to safety in the operation of trains. Practically all cars are now provided with these safeguards, and the operation of trains with less than 100 per cent efficiency in braking power, either by reason of air brakes being cut out or hand brakes being inefficient or not working in harmony with the power brakes, is seriously to be condemned.

The efficiency of hand brakes should be determined by effective tests, such precautions being as necessary to safety as are the standing and running tests of power brakes. The word "efficient" as used in the statute has recently been judicially defined as comprehending the efficiency of the hand brake for the purpose of holding a car or train, as well as its efficiency as a matter of safety to employees engaged in work requiring the use of hand brakes.

The general installation of air gauges and conductor's valves in caboose cars would provide an additional factor of safety in the operation of trains. By means of the air gauge, trainmen in the caboose may at any time note the train-line pressure, and by observing its variations will be in position to take proper measures to insure the safety of their trains should pressure fall too low.

The caboose gauge is of value also in exhibiting the variation of pressure at the rear end of a train when charging up after the train line has been cut for any purpose and recoupled, or when air brakes are released after an ordinary application.

The conductor's valve in the caboose gives to trainmen control of the braking power, and when used in cases of emergency would often serve to avoid a serious accident.

The need for these devices continually becomes more pressing owing to the tendency to operate longer and heavier trains. As the train line is increased in length the difficulty of maintaining air brakes in an efficiently operative condition progressively increases. Owing to train-pipe friction, ordinary leaks in pipe and hose connections, etc., it is often impossible to maintain adequate brake-pipe pressure at the rear of long trains or to secure the proper recharge of auxiliary reservoirs after a brake application and release. Much can be done by trainmen to remedy these unsafe conditions if they are advised of their existence, but without the air gauge at the rear of the train they must necessarily remain in ignorance of the actual condition of the brakes on their train.

Numerous inquiries have been directed to the Commission relative to the propriety of using drive screws or fluted nails to fasten running boards to saddle blocks. The Commission's order very clearly provides that running boards shall be securely fastened with screws or bolts, and the substitution of other material is not to be permitted.

Continued misapprehension on the part of railroad employees with respect to the significance of the stenciling on cars, required by the Master Car Builders' Association, warrants this repeated explanation. A car marked "United States Safety Appliances, Standard," indicates that it complies in all respects with the standardization order of March 13, 1911, while a car marked "United States Safety Appliances" signifies merely that it is a car which was in service on July 1, 1911, and which has been equipped in accordance with the provisions of the standardization order except as to those appliances permitted to remain as located during the life of the car or until its renewal as outlined in paragraphs A, D, and G of the extension order.

The spirit of cooperation exhibited by the carriers generally during the past fiscal year is admirable, and has contributed immeasurably to an effective administration of the law.

INVESTIGATION OF SAFETY DEVICES.

By a provision of the urgent deficiency act of October 22, 1913, the Commission is authorized and directed to investigate and report regarding the use and necessity for block-signal systems, appliances for the automatic control of railway trains, and any devices intended to promote the safety of railway operation, and under certain conditions to conduct experimental tests. Investigations of this character were formerly carried on by the Commission's Block Signal and Train Control Board; that board, however, was abolished on June 30, 1912, and after that date the investigation of safety devices was discontinued. In December, 1913, the Commission assigned to its Safety Appliance Division the duty of carrying out the directions contained within this provision of the act of October 22, 1913. For the purpose of conducting the investigations called for by this legislation an engineer-physicist and a signal engineer were employed, and other employees of the Commission were assigned to this work, the organization for carrying on these investigations being completed in February, 1914.

At the time this work was taken up the plans of many devices and systems intended to promote the safety of railway operation which had been presented for consideration were already in the files of the Commission, and since then plans of a considerable number of other devices have been submitted.

A circular dated December 10, 1913, setting forth the procedure necessary to be followed in submitting devices and systems for consideration was prepared and distributed. This circular quotes the legislation under which these investigations are carried on and states that any person desiring to submit for consideration an appliance or system intended to promote the safety of railway operation should forward complete specifications and detailed prints or drawings showing fully and clearly the construction, application, and method of operation of the appliance or system. All plans, specifications, drawings, and other descriptions which are furnished for examination become a part of the Commission's records and must be retained in its files. When an examination has been completed the papers furnished for such examination will not be returned. For that reason original patents, tracings, or other papers of that nature which may be of particular value to inventors or proprietors should not be furnished; instead, copies of patents, blue prints, or other descriptive papers of which duplicates can be obtained by the proprietor should be sent. The Commission can furnish no protection of the inventor's or proprietor's rights in any device submitted. When complete plans of any appliance or system have been furnished they will be placed under examination; after this examination has been completed the person submitting the device will be informed of the results thereof and the conclusions reached. Arrangements for tests will not be made until an examination of plans has been completed, and then only when the examination of plans discloses the necessity or desirability of conducting a test under service conditions. In case a test is to be made, the apparatus must be furnished, installed, and operated without expense to the Government.

On October 1, 1914, plans of 315 devices had been presented for consideration; of this number 184 had been examined and opinions regarding the devices transmitted to the proprietors. Of the number of plans examined, 131 of the devices disclosed were so impracticable or crude that they were considered practically worthless; 12 possessed meritorious features, but as a whole required further development before being entitled to serious consideration; 19 were found to disclose devices which were not intended primarily to increase safety and which would not affect the safety of railway operation sufficiently to warrant further consideration being given them in these investigations; and 22 disclosed devices which were considered to possess merit from the standpoint of safety, experimental tests of certain of these latter devices being desirable to determine their practical utility.

Brief descriptions of devices held to possess merit or approved for test are contained in the following paragraphs:

Automatic train stop, submitted by Willson-Wright Safety Appliance Co., Spokane, Wash.

This device is an application of the glass tube device; a glass tube which is carried on the car or train is intended to be struck and broken by an arm adapted to be moved into and out of operative position in conjunction with the movement of a fixed roadside signal. An installation of this system has been in service on the electric lines of the Washington Water Power Co. This device is considered to possess merit for use on electric lines, but plans of the system as developed to meet the operating conditions on steam railroads have not been presented, and unless developed to meet the requirements of such service a test would probably not result in the accumulation of data other than are already available in the records of its service on the lines of the Washington Water Power Co.

Gray-Thurber automatic train stop, presented by the Automatic Train Control & Signal Co., Pittsburgh, Pa.

This device is an automatic stop of the type employing short insulated track sections and an insulated portion of the train. A test of an installation of this system on the Pennsylvania lines west was in progress at the time the Block Signal and Train Control Board was abolished; tests of this system were also made from April 13 to July 14, 1914. As a result of these tests the conclusion was reached that, notwithstanding certain defects and deficiencies pointed out, the system in its present state of development, if properly installed and maintained as an adjunct to a block-signal system, would increase the safety of train operation.

Automatic train-control system, submitted by A. D. Pond, New Britain, Conn.

This device is a combination automatic train-stop and speed-control system employing three successive ramps for each block and an arm carried on the locomotive adapted to be raised vertically when each ramp is struck; upward movement of this arm causes a brake application unless electromagnets contained within the roadside ramps are energized and attract a pole piece carried by the locomotive; the downward movement of the locomotive arm is retarded so as to prevent the immediate restoration of the locomotive apparatus to normal condition, and this latter feature, together with proper location and spacing of the ramps, comprises the speed-control feature of the system. Provision is also made for sounding whistle signal indications in the cab. Device approved for test.

Automatic train stop, presented by the Railway Automatic Safety Appliance Co., Philadelphia, Pa.

This device is an automatic train stop of the mechanical trip type, the air-brake valve and operating mechanism being located on the locomotive pilot beam and the track instrument comprising a stand containing necessary operating mechanism and carrying a flexible arm adapted to be moved into and out of operative relation with the locomotive device. Partial tests of this system were made by the

Block Signal and Train Control Board and reported upon in its final report. Device approved for test.

Automatic train-control system, presented by the Jones Safety Train Control System Co., Baltimore, Md.

This device is of the intermittent electric contact type, employing a normally closed engine circuit which is mechanically broken when the locomotive contact shoe strikes a contact rail and an air-brake valve is operated unless the circuit is restored from an external battery current passing through the contact rail and shoe. Provision is also made for operating a cab signal to indicate clear or caution, as well as to ring a bell when a caution rail is passed, and for a train to pass deenergized contact rails at low speed. Device is in use on the Maryland & Pennsylvania Railroad. Approved for test.

Automatic train-control system, presented by the Gollos International Automatic Train Control & Recording Co., Chicago, Ill.

This device is of the intermittent electric contact type, employing a normally closed engine circuit, which is mechanically broken when the locomotive contact shoe strikes a contact rail and the locomotive apparatus is operated unless the circuit is restored from an external battery, current passing through the contact rail and shoe. Provision is made for operating cab signals and for allowing a train to pass deenergized contact rails at low speed. Device approved for test.

Automatic train stop, presented by B. F. Wooding, Denver, Colo.

This device is of the intermittent electric contact type, employing a normally closed engine circuit which is mechanically broken when the locomotive contact arm strikes a contact rail and the locomotive apparatus is operated unless the circuit is restored from an external battery, current passing through the contact rail and contact arm. Provision is also made for operating cab signals and for allowing a train to pass a deenergized contact rail at low speed. Device approved for test.

Automatic train-pipe connector, presented by J. R. Cobb, Los Angeles, Cal. Device approved for test.

Automatic train-pipe connector, presented by the Furbin Automatic Train Pipe Connector Co., St. Louis, Mo. Device approved for test.

Automatic train-pipe connector, presented by W. C. White, Baltimore, Md. Information regarding service trials desired.

Car coupler, presented by the Ironside Car Coupler Co., Kansas City, Kans. This coupler is a vertical plane coupler conforming to standard contour lines and having an extension intended to prevent a pulled-out drawbar from falling upon the track and to prevent trains from breaking in two, due to high or low couplers or rough track. The coupler also employs a special guard-arm construction to permit a coupling to be made with either or both knuckles closed. Device possesses meritorious features and information regarding results attained in practical service is desired.

Gasket for hose coupling, presented by P. R. Schuyler, Paterson, N. J. Device approved for test.

Canion air-brake system, presented by the Arizona Automatic Air Association, Baltimore, Md. Information regarding operation of this device in conjunction with other air-brake systems must be secured before a final conclusion can be reached, and therefore tests are desirable.

Rail brace, rail chair and joint, presented by R. G. Musgrove, New York, N. Y. Trial installations of these devices were inspected. These devices possess sufficient merit to warrant railroad companies giving them trials on a more extensive scale with a view to their adoption and use in situations where construction of this character is required.

Side-clearance telltale, presented by William Schwab, Sacramento, Cal.

This device consists of a pole erected at the side of the track having horizontal flexible arms extending toward the track and intended to strike a trainman on a side ladder, warning him that the car is approaching a structure near the track where the side clearance is narrow. The device would be a useful safeguard in many situations.

A number of designs of metal and concrete ties have been presented for consideration and several of them possess meritorious features, but no final conclusion regarding the practical utility of these devices as substitutes for wood ties can be formulated until the results of trials in actual service, covering a considerable period of time, are available.

The plans of two nut locks which were considered to possess merit have been examined. While these were commended as safe devices, it is believed their use would not affect the safety of railroad operation to a sufficient degree to warrant special mention.

In two instances tests which had been arranged for by the Block Signal and Train Control Board were conducted by this division, the devices tested being the following:

Automatic train stop, presented by the Jones Signal System Co., Atlanta, Ga.

This device is of the ground mechanical trip type. It was examined by the Block Signal and Train Control Board and approved for test. Negotiations for facilities to make tests of this system had been begun before the board was abolished; and later, at the instance of the Commission, the New York Central & Hudson River Railroad granted permission for an installation to be made on that road between Gratwick and La Salle, N. Y. Tests were made by this division from March 8, 1913, to March 22, 1913, inclusive, and the conclusion contained in the report covering these tests, which was transmitted to the proprietors under date of September 11, 1913, was that the device as tested in this installation can not be recommended for use under ordinary service conditions, but the faults disclosed may be corrected and the device developed to meet the needs of railroad companies.

Automatic train-pipe connector, presented by the Robinson Coupler Co., Washington, D. C.

This device was examined by the Block Signal and Train Control Board and approved for test. Preparation for tests of this device were under way when the board was abolished, and when the installation was completed the tests were made by this division, extending over the period from September 19, 1913, to September 26, 1913, inclusive. A report covering these tests was transmitted to the proprietor under date of December 1, 1913, the conclusion contained within that report being that "the Robinson connector is a safe and practicable device which, if properly installed and maintained, will meet the need for an automatic connector in general freight service and add to safety in train operation on a railroad using it."

During the past year it has been noted that a comparatively large proportion of the designs of automatic train-control systems are based upon fundamentally sound principles and possess meritorious features, and the progress in developing promising designs is evidenced also by the number of devices which have been approved for test. While most of the devices examined have been of the general types described in the reports of the Block Signal and Train Control Board, it has been found that a number of persons are working upon magnetic and inductive devices of types which have not heretofore been practically developed.

An inspection was made in March of the installation of the Miller train-control system on the Chicago & Eastern Illinois Railroad between Danville, Ill., and Hoopston, Ill., a distance of approximately 25 miles. At that time about 90 engines had been equipped, 20 of which were in service in the territory where the track installation was located.

Information has also been received regarding experiments with train-control devices on several railroads. Within the past year the American Railway Association has adopted certain definitions and requisites for installation for automatic train-control systems and has specified certain adjuncts which may be used in connection with such systems.

As noted in the foregoing, tests were made of an installation of the Gray-Thurber train-control system covering a period of approximately three months, and as a result of these tests the conclusion stated in the foregoing was reached. It is not to be expected that any device which is submitted for consideration and test will be ideal or perfect, nor that the tests contemplated by the legislation under which these investigations are carried on can result in the perfection or complete development of such devices. All that can reasonably be expected from such tests is to determine whether or not the device will operate as intended under varying operating and service conditions, as well as the conditions under which the device will break down or fail to operate, and the degree of protection afforded; in short, to determine whether or not the device is properly designed and constructed and possesses sufficient merit to warrant railroad companies in taking it up for the purpose of developing it to meet their particular operating and traffic requirements. As has been the case with railroad signal systems and other safety devices, much of the practical development of automatic train-control systems must be brought about by railroad companies themselves after those devices have been installed and placed in practical service. The tests conducted by the Block Signal and Train Control Board and by this division have demonstrated that a number of train control devices are now available which, if installed and used for the purpose intended, would increase the safety of railroad operation and which possess sufficient promise of further development to warrant railroad companies in according them serious consideration.

A tabulation of statistics pertaining to block signals, interlocking plants, and the telegraph and telephone for transmission of train orders as used on the railroads of the United States was compiled by this division and published by the Commission under date of January 1, 1914. As shown by this publication, the total length of railroad in the United States operated under the block system on January 1, 1914, was 86,736.9 miles. Of this total, 26,569.3 were automatic and 60,167.6 were nonautomatic. Comparing these figures with the corresponding figures contained in the bulletin of January 1, 1913, there was an increase of 4,350.5 miles in the length of road operated by the automatic block system and a decrease of 1,563.4 miles of road operated by the nonautomatic block system. The net increase during the year in mileage of road operated by the block system was 2,787.1 miles.

The bulletin also contains information, not heretofore published in these annual bulletins, regarding the color of night signal indications employed on different roads and the mileage on which signals are electrically lighted; also data pertaining to interlocking plants.

In this connection attention is called to the recommendation made in previous reports of the Commission for the compulsory adoption by railroads of the block system.

Respectfully submitted.

H. W. Belnap,
Chief Division of Safety.

TABLE NO. 1.—*Defective appliances on freight and passenger cars and locomotives reported by inspectors during the fiscal year 1914.*

Defects.	1914
COUPLERS AND PARTS.	
Coupler body broken	49
Coupler body missing	105
Coupler worn	141
Knuckle broken	27
Knuckle missing	39
Knuckle worn	76
Knuckle pin bent	10
Knuckle pin broken	724
Knuckle pin missing	46
Knuckle pin wrong	27
Lock block bent	641
Lock block broken	766
Lock block missing	27
Lock block inoperative	1,038
Lock block wrong	102
Lock block worn	418
Lock-block key missing	200
Lock-block trigger missing	77
Lock set missing	224
Guard arm short	1
Total	4,738
UNCOUPLING MECHANISM.	
Lock link bent	80
Lock link broken	84
Lock link missing	2
Uncoupling lever bent	388
Uncoupling lever broken	60
Uncoupling lever missing	222
Uncoupling lever incorrectly applied	354
Uncoupling lever wrong	228
Uncoupling chain broken	2,580
Uncoupling chain missing	18
Uncoupling chain kinked	593
Uncoupling chain too short	9
Uncoupling chain too long	95
End lock or casting bent	7
End lock or casting broken	34
End lock or casting loose	237
End lock or casting missing	83
End lock or casting incorrectly applied	11
End lock or casting wrong	115
Keeper bent	6
Keeper broken	109
Keeper loose	274
Keeper missing	23
Keeper incorrectly applied	8
Keeper wrong	1
Uncoupling-lever stop broken	5
Uncoupling-lever stop missing	24
Uncoupling-lever stop incorrectly applied	19
Total	5,669
AIR BRAKES.	
Air brake cut out	9,689
Cylinder and triple not cleaned within 12 months	7,021
Cylinder and triple last cleaned; no date	279
Air hose missing	219
Air hose defective	4
Air-hose gasket missing	6
Air-hose coupling defective	1
Angle cock missing	52
Angle cock defective	2
Angle-cock handle broken	227
Angle-cock handle missing	88
Train pipe broken	36
Train pipe loose	1,670
Train-pipe bracket missing	29
Crossover pipe defective	238
Cut-out cock defective	3
Cut-out cock handle broken	260
Cut-out cock handle missing	19
Cylinder casting defective	1
Cylinder loose	83
Reservoir casting defective	2
AIR BRAKES—continued.	
Reservoir loose	23
Triple-valve casting defective	6
Triple valve missing	1
Release cock defective	42
Release cock missing	13
Release rod broken	21
Release rod disconnected	174
Release rod missing	2,904
Piston travel excessive	94
Retaining pipe defective	3,189
Retaining pipe missing	73
Retaining valve defective	517
Retaining valve missing	101
Total	27,086
HANDHOLDS.	
Handhold bent	1,358
Handhold broken	95
Handhold loose	412
Handhold missing	2,226
Handhold incorrectly applied	640
Handhold too short	386
Handhold not having proper clearance	236
Total	5,353
HEIGHT OF COUPLERS.	
Coupler too high	127
Coupler too low	552
Carrier iron loose	294
Total	973
STEPS.	
Sill step bent	306
Sill step broken	18
Sill step loose	52
Sill step missing	301
Sill step incorrectly applied	50
Sill step wrong dimensions	34
Caboose platform step loose	1
Caboose platform step missing	1
Total	763
LADDERS.	
Ladder tread bent	334
Ladder tread broken	43
Ladder tread loose	158
Ladder tread missing	176
Ladder tread not having proper clearance	32
Ladder treads improperly spaced	47
Ladder loose	21
Ladder incorrectly applied	134
End ladder clearance inadequate	68
Total	1,013
RUNNING BOARDS.	
Running board broken	202
Running board loose	209
Running board missing	121
Running board wrong dimensions	33
Running board not properly secured to car	111
Running-board brace broken	133
Running-board brace loose	2,954
Running-board brace missing	487
Running-board cleat broken	322
Running-board cleat loose	141
Running-board cleat missing	206
Latitudinal extension broken	5
Latitudinal extension loose	4
Latitudinal extension missing	3
Total	4,931

TABLE NO. 1.—*Defective appliances on freight and passenger cars and locomotives reported during the fiscal year 1914*—Continued.

Defects.	1914
HAND BRAKES.	
Brake shaft bent	579
Brake shaft broken	32
Brake shaft loose	36
Brake shaft missing	283
Brake shaft incorrectly applied	5
Brake-shaft top nut missing	118
Brake-shaft cotter key or ring at bottom of shaft missing	2,141
Brake shaft wrong dimensions	8
Brake shaft with weld	4
Brake wheel broken	60
Brake wheel loose	8
Brake wheel missing	49
Brake wheel incorrectly applied	28
Brake wheel wrong dimensions	3
Ratchet wheel broken	10
Ratchet wheel loose	275
Ratchet wheel missing	19
Ratchet wheel incorrectly applied	90
Ratchet wheel wrong dimensions	1
Ratchet wheel insufficient teeth	1
Brake pawl broken	25
Brake pawl loose	188
Brake pawl missing	137
Brake pawl incorrectly applied	76
Brake step broken	92
Brake step loose	39
Brake step missing	1
Brake step incorrectly applied	1
Brake-step brace broken	10
Brake-step brace loose	11
Brake-step brace incorrectly applied	1
Brake-shaft stirrup bent	15
Brake-shaft stirrup broken	4
Brake-shaft stirrup loose	75
Brake-shaft stirrup missing	7
Brake-shaft stirrup wrong	8
Top brake-shaft support broken	11
Top brake-shaft support loose	268
Top brake shaft support missing	35
Top brake-shaft support incorrectly applied	3
Top brake-shaft bracket bent	1
Top brake shaft bracket broken	5
Top brake-shaft bracket loose	52
Top brake-shaft bracket missing	8
Brake chain broken	168
Brake chain missing	45
Brake chain wrong dimensions	3
Brake chain too long	28
Brake chain not properly fastened to brake-shaft drum	107
Hand-brake rod broken	6
Hand-brake rod missing	7
Hand-brake rod too long	10
Hand-brake rod disconnected	20
Floating lever disconnected	1
Floating-lever guide broken	7
Floating-lever guide loose	44
Floating-lever guide missing	1
Floating-lever fulcrum broken	2
Floating-lever fulcrum loose	30
Top truck rod broken	12
Top truck rod disconnected	19
Top truck rod missing	15
Bottom truck rod broken	11
Bottom truck rod disconnected	6
Bottom truck rod missing	72
Truck live lever disconnected	5
Truck live lever missing	11
Truck dead lever broken	3
Truck dead lever disconnected	74
Truck dead lever missing	18
Truck dead-lever fulcrum broken	14
Truck dead-lever fulcrum disconnected	29
Truck dead-lever fulcrum missing	7
Cylinder lever disconnected	6
Cylinder-lever guide broken	3
Cylinder-lever guide loose	13
HAND BRAKES—continued.	
Cylinder-lever guide missing	1
Brake beam bent	6
Brake beam broken	9
Brake beam missing	48
Brake-beam fulcrum broken	6
Brake-beam fulcrum loose	3
Brake-beam fulcrum missing	3
Brake head broken	5
Brake head loose	2
Brake head missing	4
Brake shoe broken	198
Brake shoe missing	243
Brake-shoe key broken	20
Brake-shoe key missing	65
Brake hanger broken	15
Brake hanger loose	24
Brake hanger missing	6
Brake-hanger hook or casting broken	1
Brake-hanger hook or casting loose	6
Brake-hanger hook or casting missing	2
Cylinder rod broken	4
Cylinder rod disconnected	6
Cylinder rod missing	3
Total	6,300
SAFETY RAILINGS.	
Safety railing broken	1
Safety railing missing	10
Safety railing wrong dimensions	1
Total	12
FOOTBOARDS.	
Footboard broken	20
Footboard loose	4
Footboard missing	17
Footboard incorrectly applied	101
Footboard wrong dimensions	39
Total	181
PILOT-BEAM SILL STEPS.	
Pilot-beam sill step bent	9
Pilot-beam sill step broken	4
Pilot-beam sill step loose	2
Pilot-beam sill step missing	117
Pilot-beam sill step incorrectly applied	6
Pilot-beam sill step wrong dimensions	3
Total	141
HANDRAILS.	
Handrail loose	3
Handrail missing	153
Handrail incorrectly applied	13
Handrail wrong dimensions	5
Total	174
STEPS FOR HEADLIGHTS.	
Step for headlight broken	1
Step for headlight missing	31
Total	32
POWER BRAKES.	
Pump missing	1
Power driving-wheel brake missing	3
Power driving-wheel brake defective	9
Total	13
ASH PANS.	
Ash pan defective	5
Grand total	53,384

SUMMARY.

Freight cars inspected	790, 822
Freight cars defective	45, 862
Per cent defective	5. 79
Defects reported	54, 377
Passenger cars inspected	26, 746
Passenger cars defective	280
Per cent defective	1. 04
Defects reported	448
Locomotives inspected	32, 761
Locomotives defective	1, 634
Per cent defective	4. 98
Defects reported	2, 559

NUMBER OF DEFECTS PER 1,000 INSPECTED.

Couplers and parts	5. 56
Uncoupling mechanism	6. 67
Visible parts of air brakes	31. 83
Handholds	6. 30
Height of couplers	1. 14
Steps	. 88
Ladders	1. 19
Running boards	5. 80
Hand brakes	7. 40
Safety railings	. 01
Footboards	. 21
Pilot-beam sill steps	. 17
Handrails	. 20
Steps for headlights	. 04
Power brakes	. 02
Ash pans	. 01
All classes	67. 48

TABLE No. 2.—*Railroads upon which 500 or more cars were inspected during the fiscal year ending June 30, 1914, showing the total number of defects reported under each of the classifications, represented by figures 1 to 19.*

1. Couplers and parts.
2. Uncoupling mechanism.
3. Visible parts of air brakes.
4. Handholds.
5. **Height of couplers.**
6. Steps.
7. Ladders.
8. Running boards.
9. Hand brakes.
10. Safety railings.
11. Footboards.
12. Pilot beam sill steps.
13. Handrails.
14. Steps for headlights.
15. Power brakes.
16. Ash pans.
17. Grand total, all defects.
18. Total cars and locomotives.
19. Total defective.

Name of road.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Alabama & Vicksburg		7	34					7	14								62	806	59
Alabama Great Southern	30	17	129	9	1		1	20	23								230	2,403	206
Ann Arbor	1	2	44	3	1		6	5	1								63	994	55
Atchison, Topeka & Santa Fe	630	135	202	205	18	3	22	122	83		1		29				1,450	30,570	1,256
Atlanta, Birmingham & Atlantic	7	26	53	9				23	15								133	1,234	114
Atlantic Coast Line	32	129	465	62	6	15	38	65	243		2		2				1,059	11,924	872
Baltimore & Ohio	107	158	703	114	5	14	26	82	100		3		6				1,318	22,310	1,176
Baltimore & Ohio Southwestern	17	13	49	6	5	1		27	5								123	2,022	106
Bangor & Aroostook	13	13	84	6	2	1		2	29		1						151	1,531	144
Bessemer & Lake Erie		4	27	2			1	4	4								42	761	40
Boston & Albany	18	31	241	27	21	10	12	71	54		1		1		1		488	9,422	433
Boston & Maine	121	237	1,360	129	101	31	32	278	290		17				3		2,599	28,158	2,281
Buffalo, Rochester & Pittsburgh	5	14	36	6			1	4	13								79	2,003	74
Central New England	3	5	33	3	3			6	5				2				60	1,577	54
Central of Georgia	9	40	95	21	2	5	3	43	37				1				256	3,444	226
Central of New Jersey	7	40	128	23	3	2	6	47	23		1						280	5,811	235
Central Vermont	29	50	359	33	26	7	7	97	77		2	1		2	1		691	5,818	535
Charleston & Western Carolina	4	12	55	13		4	4	12	25								129	1,176	92
Chesapeake & Ohio	61	97	648	48	5	2	14	47	68		2		2		1		995	13,409	864
Chicago & Alton	24	37	299	26	5	2	5	33	64		3						498	4,823	408
Chicago & Eastern Illinois	15	19	107	14		1	2	18	20		1						197	2,755	180
Chicago & North Western	82	166	1,019	204	43	39	50	134	413		5		1				2,156	18,920	1,841
Chicago, Burlington & Quincy	169	136	557	49	23	21	77	87	150		3						1,272	20,348	1,082
Chicago Great Western	10	20	131	17	2	4	4	13	27		1	4	1				234	3,530	204
Chicago, Indianapolis & Louisville	5	4	58	31		1	3	4	3		2		1				112	1,117	79
Chicago, Milwaukee & St. Paul	72	127	884	212	70	22	28	103	387		7	5	1				1,918	21,514	1,618
Chicago, Rock Island & Gulf	5	10	10	8			1		8		4						46	792	38
Chicago, Rock Island & Pacific	151	198	888	133	36	18	41	257	259	1	8				1		1,991	18,640	1,592
Chicago, St. Paul, Minneapolis & Omaha	40	91	276	121	8	8	18	65	110					1			738	10,173	588
Cincinnati, Hamilton & Dayton	18	36	146	23		2	3	26	17		1						272	3,250	242
Cincinnati, New Orleans & Texas Pacific	125	90	506	58	17		3	56	28		1	2		1			887	11,463	812
Cleveland, Cincinnati, Chicago & St. Louis	43	49	400	31	14	2	12	79	55		3					1	689	10,857	614
Colorado & Southern	50	14	28	20	6	2	6	8	27				1				162	3,549	140
Cumberland Valley		1	6	1													8	758	8
Delaware & Hudson Co.	8	17	94	7	2	1	4	13	9								155	9,044	145
Delaware, Lackawanna & Western	17	50	187	37	6	2	31	43	9		1						383	15,025	340
Denver & Rio Grande	82	48	39	23	16	2	12	18	19		3	1	3				266	11,872	224
Elgin, Joliet & Eastern	6	13	69	3	1			14	20			26					152	1,053	117

TABLE NO. 2.—*Railroads upon which 500 or more cars were inspected during the fiscal year ending June 30, 1914, showing the total number of defects reported under each of the classifications, represented by figures 1 to 19*—Continued.

Name of road.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
El Paso & Southwestern	45	5	9	9	3	1		17	9								98	1,996	83
Erie	18	85	419	37	9	3	5	82	40				1				699	15,336	617
Florida East Coast	3	7	15	7				1	29								62	1,112	57
Fort Worth & Denver City	32	6	29	11	2	1	8	15	3		1	2	1				111	2,016	98
Fort Worth & Rio Grande	6	13	3	12	3			3	2								42	695	26
Galveston, Harrisburg & San Antonio	14	36	20	21	3	1	4	13	21								133	4,173	109
Georgia Southern & Florida	3	13	20	2				9	11			1					59	670	51
Grand Trunk	10	35	176	65	10	3	5	82	31	1	1	22	14				455	5,032	350
Great Northern	77	45	363	113	19	11	16	70	155		2		6	1			878	12,198	752
Green Bay & Western	2		23	8		1		2	13				8				57	515	53
Gulf & Ship Island	1	9	30	2				7	19								68	1,893	68
Gulf, Colorado & Santa Fe	40	64	65	33	7	2	5	10	72		2	2	1				303	4,831	267
Hocking Valley	3	9	86	13	1		2	6	14		1						135	1,446	126
Houston & Texas Central	33	31	40	38	2	2	3	5	22								176	3,778	149
Houston Belt & Terminal	10	9	1	5			2	1	4								32	654	31
Illinois Central	174	167	1,524	104	57	17	36	269	278			6					2,632	30,071	2,246
International & Great Northern	25	43	51	40	4	5	9	7	37		2		1				224	6,310	186
Kansas City Southern	20	13	66	14	6	2	4	5	17		1				1		149	2,468	123
Kentucky & Indiana Terminal	9	22	109	11			1	4	9								165	1,542	148
Lake Erie & Western		2	26			1		4	1								34	685	31
Lake Shore & Michigan Southern	20	36	364	24	1	1	25	62	37		2						572	15,918	499
Lehigh Valley	14	92	284	48	1	5	1	56	22		4	1					528	12,603	484
Long Island	1	11	59	10	1	2	3	10	8		1	1					107	1,679	89
Louisville & Nashville	36	53	305	46	12	7	6	65	67								597	16,007	555
Maine Central	5	11	101	18	9	2	2	14	18		1						181	2,454	173
Michigan Central	7	11	96	12		2	3	39	12								182	3,986	161
Midland Valley	5	3	26	2	1			4	6		2						49	634	41
Minneapolis & St. Louis	15	25	217	25	9	4	4	34	48			2					383	2,919	292
Minneapolis, St. Paul & Sault Ste. Marie	11	39	269	46	3	6	14	32	49		1	4	1				475	7,994	438
Minnesota Transfer	1	5	20	2		1		6	3								38	686	33
Missouri, Kansas & Texas	64	99	191	53	11	4	9	15	65		4	1					516	7,769	444
Missouri, Kansas & Texas of Texas	6	24	18	9	1	1	3	4	14								80	1,525	70
Missouri Pacific	70	47	447	44	11	2	17	58	66	1	1						764	8,765	643
Mobile & Ohio	16	42	409	16	4	5	1	57	69	1	1	1	6	1			629	6,261	552
Morgan's Louisiana & Texas	2	8	2	1			1	1	3								18	897	16
Nashville, Chattanooga & St. Louis	18	13	59	13	1			20	11								135	3,220	113
New Orleans & Northeastern	6	30	236	6		3	1	57	62		1						402	4,358	370
New Orleans, Mobile & Chicago	1	3	27	4				12	12								59	819	59
New Orleans Terminal Co	2	5	26					11	15								59	855	50
New York Central & Hudson River	44	103	306	48	3	13	18	83	59			2					879	25,212	777
New York, Chicago & St. Louis	3	8	107	10				12	4		1						145	2,349	130
New York, New Haven & Hartford	54	149	838	115	19	14	38	197	218		5		1		2		1,650	23,705	1,407
New York, Ontario & Western	8	7	35	3		1	1	4	3								62	4,499	56
New York, Susquehanna & Western		6	10	1					1								18	548	17

Norfolk & Western	5	17	136	19	1	6	1	22	27		2						236	8,417	209
Norfolk Southern	2	7	39	17		1	1	16	8				1				92	554	71
Northern Central	1	2	6	1				1	2								13	1,106	10
Northern Pacific	191	107	402	124	19	16	36	131	186		3		3	2			1,220	16,610	978
Northern Pacific Terminal	6	4	1	1				1	3								16	1,220	16
Oregon Short Line	96	21	59	43	11	5	7	3	11		2		7	11			276	7,590	244
Oregon-Washington Railroad & Navigation Co	28	12	22	26	8		3	3	4		5		4				115	4,201	91
Pecos & Northern Texas	9	3	6	3			1		6								28	834	28
Pennsylvania Co	24	20	99	27		2	2	9	12		5						200	5,117	173
Pennsylvania Railroad	52	68	285	30	2	6	8	28	47								526	29,360	478
Peoria & Pekin Union	9	4	45	2	6	1	3	5	7								82	1,063	71
Pere Marquette	13	50	255	49	3	1	1	49	18		1						440	3,666	376
Philadelphia & Reading	11	17	102	10	6	3	1	44	33								227	7,017	197
Pittsburgh & Lake Erie	7	6	22	6				5	3								49	1,261	45
Pittsburgh, Cincinnati, Chicago & St. Louis	2	3	16				1	8	5								35	588	31
Rutland	6	21	78	4	6	1	2	11	18				1				148	2,926	126
St. Johns River Terminal	2	3	36	3				3	15								62	690	56
St. Louis & San Francisco	173	121	995	119	40	4	12	119	124		1		1	1			1,710	12,643	1,417
St. Louis, Iron Mountain & Southern	43	74	707	56	26	3	10	104	93		5						1,121	7,137	909
St. Louis Southwestern	17	26	93	12			3	3	15		4						173	2,773	148
San Antonio & Aransas Pass	2	29	22	19	6	2			10				1				91	2,505	82
San Pedro, Los Angeles & Salt Lake	49	11	15	9	6	3	4	4	4		1		1				107	4,552	100
Seaboard Air Line	45	83	646	54	8	6	8	142	168		2	1	1				1,164	9,927	1,015
Southern	87	283	929	160	35	25	19	289	172		1						2,000	22,906	1,652
Southern in Mississippi	7	14	91	1	1	1		20	16								151	1,159	131
Southern Pacific Co	268	66	133	87	27	11	26	56	57				6	1			738	27,022	671
Spokane, Portland & Seattle	12	4	7	10		3	9	5	3								53	1,661	28
Terminal Railroad Association of St Louis	26	52	322	38	11	4	6	31	52								542	3,183	457
Texarkana & Fort Smith	8	11	1	8			1	2									31	645	24
Texas & New Orleans	10	15	10	6		2	2	1	10		2						58	1,844	49
Texas & Pacific	31	33	69	42	6	1	3	17	42		1			1			246	4,985	209
Toledo & Ohio Central	3	16	85	13				8	11		3		9				148	1,807	139
Toledo, St. Louis & Western	3	11	56	11	2			8	2		1		4				98	990	83
Ulster & Delaware	2	1	12				1		2								18	905	15
Union Pacific	51	34	63	19	7	1	9	19	22		1						226	17,243	188
Union Railway (Memphis)	14	11	145	8	2	4	1	17	25								227	1,205	187
Union Stock Yards Co. (Omaha)	8	3	4	1			1	1	2								20	1,277	19
Vandalia	2		28				1		4								35	804	35
Vicksburg, Shreveport & Pacific	9	14	3	3	1				6								36	651	29
Virginian			33	11			21		5								70	1,966	62
Wabash	67	94	559	63	21	6	18	89	112		7						1,036	9,644	873
Washington Southern	3	4	22	2				6	12								49	1,563	42
Western & Atlantic		1	16	3			2	5	4								31	591	29
Western Maryland	6	11	107	8	4	4	7	7	16		1						171	2,807	151
Western of Alabama	2	13	53	5	2	1	3	19	20				1				119	2,344	105
Western Pacific	50	12	14	9	7			3	2								97	2,467	77
West Shore	11	15	93	5			1	17	9								151	2,873	127
Wheeling & Lake Erie		5	38	1				5	3								52	838	47
Yazoo & Mississippi Valley	39	48	376	35	6	3	5	47	71								630	4,839	543

See table No. 1, which shows in detail the defects making up each of the above classifications.

TABLE NO. 3.—*Terminal tests of air brakes from July 1, 1913, to June 30, 1914.*

Name of road.	Trains.	Cars.	Air cars.	Nonair cars.	Brakes cut out.	Brakes that did not apply.	Brakes that operated.	Cars not controlled by air.	Cars controlled by air.	Per cent of cars controlled by air.	Brakes with excessive piston travel.
Abilene & Southern	3	17	17	....	1	2	14	3	14	83	1
Alabama Great Southern	1	42	42	....	....	....	42	....	42	100	....
Arizona & New Mexico	1	27	27	....	....	....	27	....	27	100	....
Atchison, Topeka & Santa Fe	67	2,564	2,564	....	16	93	2,455	109	2,455	96	....
Atlanta, Birmingham & Atlantic	1	17	17	....	....	2	15	2	15	88	....
Atlantic Coast Line	12	291	291	....	4	12	275	16	275	95	12
Baltimore & Ohio	9	255	255	....	2	11	242	13	242	95	2
Baltimore & Ohio Southwestern	3	85	85	....	2	3	80	5	80	95	....
Bangor & Aroostook	6	193	193	....	5	17	171	22	171	89	1
Bessemer & Lake Erie	2	86	84	2	....	5	79	7	79	92	....
Birmingham & Southeastern	2	8	8	....	1	1	7	1	7	87	....
Birmingham, Columbus & St. Andrews	1	4	4	....	....	....	4	....	4	100	....
Boston & Albany	12	392	392	....	5	45	342	50	342	88	1
Boston & Maine	82	2,676	2,676	....	37	227	2,412	264	2,412	90	26
Buffalo, Rochester & Pittsburgh	2	38	38	....	2	....	36	2	36	95	....
Burr's Ferry, Browndel & Chester	1	3	3	....	....	1	2	1	2	66	....
Central New England	3	104	104	....	1	11	92	12	92	89	2
Central of Georgia	5	99	99	....	1	2	96	3	96	97	....
Central Railroad of New Jersey	4	143	143	....	1	6	136	7	136	95	....
Central Vermont	8	142	142	....	1	10	131	11	131	92	4
Charlotte Harbor & Northern	1	8	8	....	....	2	6	2	6	75	1
Chattahoochee Valley	2	4	3	1	....	....	3	1	3	75	....
Chesapeake & Ohio	5	68	67	1	....	4	63	5	63	93	....
Chesapeake Western	3	24	24	....	....	....	24	....	24	100	....
Chicago & Eastern Illinois	2	60	60	....	5	....	55	5	55	91	....
Chicago & North Western	9	187	187	....	8	16	163	24	163	87	1
Chicago, Burlington & Quincy	14	405	405	....	3	15	387	18	387	96	....
Chicago, Indianapolis & Louisville	1	42	42	....	2	1	39	3	39	93	....
Chicago, Memphis & Gulf	1	5	5	....	....	....	5	....	5	100	....
Chicago, Milwaukee & St. Paul	3	68	68	....	....	6	62	6	62	91	2
Chicago, Rock Island & Pacific	21	619	619	....	30	54	535	84	535	86	5
Chicago, St. Paul, Minneapolis & Omaha	2	124	124	....	....	1	123	1	123	99	....
Cincinnati, New Orleans & Texas Pacific	5	89	89	....	3	2	84	5	84	94	....
Cleveland, Cincinnati, Chicago & St. Louis	4	188	188	....	8	4	176	12	176	93	....
Coal & Coke	3	72	69	3	....	4	65	7	65	90	....
Colorado & Southern	4	89	89	....	....	....	89	....	89	100	....
Coudersport & Port Allegany	2	20	20	....	6	....	14	6	14	70	....
Delaware & Hudson	32	1,443	1,443	....	10	44	1,389	54	1,389	96	....
Delaware, Lackawanna & Western	12	545	545	....	4	14	527	18	527	97	....
Denver & Rio Grande	10	318	311	7	....	7	304	14	304	95	....
Detroit & Toledo Shore Line	1	51	51	....	1	2	48	3	48	94	....
Detroit, Toledo & Ironton	1	57	57	....	2	3	52	5	52	91	3
East Tennessee & Western North Carolina	1	5	5	....	....	....	5	....	5	100	....

El Paso & Southwestern	5	158	158			3	155	3	155	98	
Erie	12	521	514	7	4	40	470	51	470	90	3
Florida Central	1	3	3				3		3	100	
Florida East Coast	2	68	68			14	54	14	54	80	
Florida Ry	1	5	5			1	4	1	4	80	
Fort Worth & Denver City	5	130	130			1	129	1	129	99	
Galveston, Harrisburg & San Antonio	14	355	355		1	37	317	38	317	89	10
Georgia & Florida	1	13	13			2	11	2	11	85	
Georgia Coast & Piedmont	1	7	7			1	6	1	6	85	
Georgia, Florida & Alabama	3	20	20		2	1	17	3	17	85	1
Georgia Northern	1	11	11			1	10	1	10	91	
Georgia Southwestern & Gulf	2	14	14				14		14	100	1
Grand Trunk	1	28	28		2	4	22	6	22	78	
Great Northern	7	236	236		10	15	211	25	211	89	6
Gulf & Ship Island	2	45	45		2		43	2	43	95	
Gulf, Colorado & Santa Fe	12	269	269		2	8	259	10	259	96	9
Gulf, Texas & Western	1	6	6			1	5	1	5	83	
Houston East & West Texas	1	35	35			1	34	1	34	97	1
Houston & Texas Central	5	171	171		3	14	154	17	154	90	4
Illinois Central	19	485	485		11	64	410	75	410	85	16
Illinois Southern	1	23	22	1	5	3	14	9	14	64	2
International & Great Northern	19	504	504		1	55	448	56	448	89	11
Joplin Union Depot	1	11	11			1	10	1	10	91	
Kansas City & Memphis	1	8	8				8		8	100	
Kansas City, Mexico & Orient	4	109	109			6	103	6	103	94	
Kansas City Southern	5	151	151		2	12	137	14	137	91	4
Lake Charles & Northern	1	28	28			5	23	5	23	82	1
Lake Erie & Western	1	19	19		1		18	1	18	95	
Lake Shore & Michigan Southern	2	78	78		1	2	75	3	75	96	1
Lehigh Valley	14	636	630	6	8	47	575	61	575	90	14
Louisiana & Arkansas	1	14	14				14		14	100	1
Louisiana & Pacific	1	14	14			3	11	3	11	79	
Louisville & Nashville	6	164	164			5	159	5	159	96	
Louisville, Henderson & St. Louis	1	20	20			1	19	1	19	95	
Maine Central	13	376	376		2	28	346	30	346	92	8
Marianna & Blountstown	1	5	5				5		5	100	
Michigan Central	1	25	25		1		24	1	24	96	
Midland Valley	1	28	28		3	4	21	7	21	82	
Missouri & North Arkansas	1	13	13		1		12	1	12	92	
Missouri, Kansas & Texas	18	421	421		9	35	377	44	377	90	8
Missouri Pacific	9	252	252		7	13	232	20	232	92	
Mobile & Ohio	1	12	12				12		12	100	
Nashville, Chattanooga & St. Louis	3	101	101			2	99	2	99	98	2
New Orleans Great Northern	1	11	11		1		10	1	10	91	
New Orleans & Northeastern	1	24	24		3		21	3	21	88	
New Orleans, Mobile & Chicago	1	13	13			1	12	1	12	92	
New York Central & Hudson River	9	425	425		3	41	381	44	381	90	3
New York, Chicago & St. Louis	5	168	168		5	2	161	7	161	95	
New York, New Haven & Hartford	44	1,494	1,492	2	10	112	1,370	124	1,370	92	3
New York, Ontario & Western	7	200	200				200		200	100	
Northern Pacific	4	199	199			11	188	11	188	94	2
Oregon Short Line	5	222	222			23	199	23	199	90	
Oregon-Washington Railroad & Navigation Co	1	46	46				46		46	100	4

TABLE NO. 3.—*Terminal tests of air brakes from July 1, 1913, to June 30, 1914*—Continued.

Name of road.	Trains.	Cars.	Air cars.	Nonair cars.	Brakes cut out.	Brakes that did not apply.	Brakes that operated.	Cars not controlled by air.	Cars controlled by air.	Per cent of cars controlled by air.	Brakes with excessive piston travel.
Pacific Electric Railway	1	7	7				7		7	100	
Pecos & Northern Texas	2	106	106			4	102	4	102	96	
Pennsylvania Railroad	17	569	569		1	28	540	29	540	95	3
Pennsylvania Lines	8	355	355		5	4	346	9	346	97	
Pere Marquette	4	156	154	2	12	13	129	27	129	83	2
Philadelphia & Reading	2	81	81			8	73	8	73	90	
Pierre, Rapid City & North Western	2	28	28			2	26	2	26	93	
Pittsburgh & Lake Erie	3	175	175		1	2	172	3	172	98	
Port Bolivar Iron Ore	1	7	7			1	6	1	6	86	
Rutland	4	166	166		2	5	159	7	159	96	2
St. Johns River Terminal	1	48	48			5	43	5	43	90	5
St. Louis & San Francisco	10	301	301		6	25	270	31	270	90	6
St. Louis, Brownsville & Mexico	4	50	50			3	47	3	47	94	
St. Louis, Iron Mountain & Southern	13	452	452		22	7	423	29	423	94	1
St. Louis, San Francisco & Texas	1	24	24			2	22	2	22	92	
St. Louis Southwestern	5	180	180		3	21	156	24	156	87	2
San Antonio & Aransas Pass	7	138	138		1	18	119	19	119	86	4
San Pedro, Los Angeles & Salt Lake	19	616	616		1	7	608	8	608	98	
Seaboard Air Line	14	335	335		7	14	314	21	314	93	3
Southern	12	421	421		8	49	364	57	364	86	6
Southern Railway in Mississippi	1	7	7				7		7	100	1
Southern Pacific	42	1,609	1,609		3	36	1,570	39	1,570	97	
Sugarland	1	19	19			3	16	3	16	84	
Tavares & Gulf	1	7	7				7		7	100	1
Texas & Gulf	1	14	14			2	12	2	12	86	
Texas & New Orleans	4	81	81		2	4	75	6	75	92	4
Texas & Pacific	17	409	409		1	33	375	34	375	91	15
Texas Central	2	45	45			6	39	6	39	87	
Texas Mexican	2	11	11		1		10	1	10	91	
Texas Midland	2	34	34			4	30	4	30	88	
Trinity & Brazos Valley	2	78	78		1	6	71	7	71	91	5
Ulster & Delaware	1	7	7				7		7	100	
Union Pacific	16	689	689			25	664	25	664	96	1
Union Stock Yards	1	24	24				24		24	100	
Vicksburg, Shreveport & Pacific	1	21	21			3	18	3	18	86	1
Wabash	14	536	536		17	44	475	61	475	89	13
Western Pacific	1	43	43				43		43	100	1
West Shore	3	64	64		5		59	5	59	92	
Wichita Valley	2	18	18			4	14	4	14	78	1
Wrightsville & Tennille	1	9	9				9		9	100	2
Grand total	889	28,011	27,979	32	360	1,634	25,985	2,026	25,985	92	255

TABLE No. 4.—*Condition of safety appliances on the freight cars of a few representative railroads, showing the prevailing general conditions during the past 5 years.*

[Compiled from reports of the Commission's inspectors.]

Name of road.	1914			1913			1912			1911			1910		
	In-spected.	Defec-tive.	Per cent defectiv .	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.
Alabama Great Southern	2,272	204	8.9	2,419	180	7.4	532	36	6.7	644	35	5.4	698	49	7.0
Ann Arbor	967	55	5.6	459	47	10.2	491	27	5.5	412	18	4.3	839	49	5.8
Atchison, Topeka & Santa Fe	27,416	1,175	4.2	31,581	1,564	4.9	23,488	1,382	5.8	21,405	923	4.3	25,692	1,156	4.5
Atlanta, Birmingham & Atlantic	1,118	110	9.8	2,132	217	10.2	264	21	7.9	693	44	6.3	91	11	12.0
Atlantic Coast Line	10,961	851	7.7	11,463	959	8.3	5,362	393	7.3	3,704	128	3.4	4,142	264	6.1
Baltimore & Ohio	21,358	1,161	5.4	18,526	989	5.3	12,365	452	3.6	13,790	631	3.3	13,152	402	3.0
Baltimore & Ohio Southwestern	1,958	106	5.4	1,976	115	5.8	1,069	44	4.1	1,785	79	4.4	667	19	2.8
Bangor & Aroostook	1,367	130	9.5	1,342	116	8.6	1,587	93	5.8	1,487	31	2.1	365	14	3.8
Bessemer & Lake Erie	732	40	5.4	912	52	5.7	1,451	105	7.2	1,066	33	3.1	838	39	4.6
Boston & Albany	8,063	394	4.8	6,566	562	8.4	3,880	147	3.7	2,434	54	2.2	2,699	60	2.2
Boston & Maine	24,510	2,088	8.5	22,758	2,524	11.1	12,320	617	5.0	8,793	295	3.3	7,461	241	3.2
Buffalo & Susquehanna	233	5	2.1	736	16	2.1	266	15	5.6	646	24	3.7	315	30	9.5
Buffalo, Rochester & Pittsburgh	1,851	74	3.9	1,753	53	3.0	1,597	53	3.3	2,119	31	1.4	1,525	30	1.9
Carolina, Clinchfield & Ohio	375	16	4.2	265	18	6.7	258	14	5.4	597	26	4.3	494	15	3.0
Central of Georgia	3,183	222	6.9	5,216	406	7.5	2,046	209	10.2	1,723	45	2.6	2,129	92	4.3
Central Railroad of New Jersey	5,253	225	4.2	3,800	130	3.4	3,531	81	2.3	4,090	93	2.2	2,374	96	4.0
Central Vermont	5,235	488	9.3	4,720	650	13.7	2,628	186	7.1	1,891	124	6.5	1,328	60	4.5
Chesapeake & Ohio	12,784	853	6.6	9,842	626	6.3	6,948	508	7.3	5,438	299	5.5	5,844	392	6.7
Chicago & Alton	4,546	398	8.7	4,031	457	11.3	2,659	285	10.7	3,201	403	12.6	3,078	321	10.4
Chicago & Eastern Illinois	2,659	178	6.7	2,328	148	6.3	2,260	180	7.9	897	57	6.3	1,465	84	5.7
Chicago & North Western	18,387	1,826	9.9	21,037	3,054	14.5	8,255	1,206	14.6	13,276	1,114	8.4	10,830	918	8.4
Chicago, Burlington & Quincy	19,066	1,051	5.5	20,410	1,577	7.2	11,981	971	8.1	11,816	705	5.9	10,266	854	8.3
Chicago Great Western	3,375	195	5.7	2,511	192	7.6	2,539	261	10.2	1,497	66	4.4	1,728	128	7.4
Chicago, Indianapolis & Louisville	1,071	77	7.1	1,503	161	10.7	368	13	3.5	1,034	58	5.6	395	16	4.0
Chicago, Milwaukee & Puget Sound	112	6	5.3	1,071	48	4.4	2,384	39	1.6	2,933	98	3.3	1,734	70	4.0
Chicago, Milwaukee & St. Paul	20,781	1,559	7.5	20,775	2,234	10.7	8,998	774	8.6	14,450	701	4.7	9,006	505	5.6
Chicago, Rock Island & Gulf	742	32	4.3	696	45	6.4	533	48	9.0	785	21	2.6	728	42	5.8
Chicago, Rock Island & Pacific	17,195	1,531	8.9	17,783	1,489	8.3	8,444	715	8.4	11,755	770	6.5	11,435	750	6.5
Chicago, St. Paul, Minneapolis & Omaha	9,915	572	5.7	6,205	522	8.4	1,813	176	9.7	4,955	230	4.6	3,774	154	4.0
Cincinnati. Hamilton & Dayton	3,030	241	7.9	3,076	278	9.0	1,033	82	7.9	1,392	65	4.6	812	40	4.9
Cincinnati, New Orleans & Texas Pacific	11,045	794	7.1	6,525	561	8.5	3,514	311	8.8	2,585	171	6.6	1,941	183	9.4
Cleveland, Cincinnati, Chicago & St. Louis	10,555	603	5.7	11,789	715	6.0	7,177	490	6.8	10,897	547	5.0	7,184	401	5.6
Colorado & Southern	3,380	137	4.5	3,242	143	4.4	2,995	139	4.6	3,628	113	3.1	4,257	172	4.0
Colorado Midland	293	5	1.7	205	2	.9	722	51	7.0	734	28	3.8	994	88	8.9
Delaware & Hudson Co	8,341	140	1.6	6,571	137	2.0	5,741	95	1.1	3,941	51	1.3	5,257	89	1.7
Delaware, Lackawanna & Western	13,684	330	2.4	12,002	310	2.5	7,458	159	2.1	7,790	107	1.3	8,746	206	2.3

TABLE NO. 4.—*Condition of safety appliances on the freight cars of a few representative railroads, showing the prevailing general condition during the past 5 years*—Continued.

Name of road.	1914			1913			1912			1911			1910		
	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.	In-spected.	Defec-tive.	Per cent defec-tive.
Denver & Rio Grande	11,088	212	1.9	13,348	580	4.3	10,975	619	5.6	10,064	276	2.7	11,746	453	3.8
Detroit, Toledo & Ironton	294	23	7.8	859	68	7.9	305	14	4.6	796	51	6.4	140	9	6.4
Duluth, Missabe & Northern	205			131			189	17	8.9	934	13	1.4	660	24	3.6
Duluth, South Shore & Atlantic	399	14	3.5	748	94	12.5	602	5	.8	599	4	.7	929	8	.8
Elgin, Joliet & Eastern	1,024	103	10.0	808	99	12.2	176	25	14.2	134	9	6.7	496	66	13.3
El Paso & Southwestern	1,829	72	3.9	1,975	89	4.5	1,484	138	9.3	1,404	41	2.9	1,940	128	6.6
Erie	14,278	613	4.2	16,568	228	4.9	10,435	607	5.8	9,167	393	4.3	11,661	454	3.9
Fort Worth & Denver City	1,848	89	4.8	1,311	87	6.6	1,966	185	9.4	2,154	91	4.2	2,291	62	2.7
Galveston, Harrisburg & San Antonio	3,698	102	2.7	3,401	231	6.7	2,710	199	7.3	916	18	1.9	1,046	43	4.1
Georgia, Southern & Florida	599	44	7.3	896	63	7.0	415	42	10.1	79	5	6.3	470	38	8.1
Grand Trunk	4,749	308	6.4	7,811	533	6.8	4,205	242	5.7	4,127	139	3.3	5,783	207	3.6
Great Northern	11,695	722	6.1	10,719	1,162	10.8	5,322	216	4.0	9,165	519	5.6	8,034	500	6.2
Gulf & Ship Island	1,707	68	4.0	1,315	88	6.6	1,202	41	3.4	511	47	9.2	477	39	8.2
Gulf, Colorado & Santa Fe	4,386	260	5.9	2,568	146	5.6	1,633	129	7.9	2,216	123	5.5	1,934	114	5.9
Hocking Valley	1,402	125	8.9	420	31	7.3	675	28	4.1	895	17	1.9	653	7	1.1
Houston & Texas Central	3,357	144	4.2	3,597	227	6.3	2,114	164	7.7	3,374	46	1.3	1,927	43	2.2
Illinois Central	28,581	2,223	7.7	24,859	2,676	10.7	14,753	1,346	9.1	8,434	661	7.8	7,796	528	6.8
International & Great Northern	5,675	174	3.0	3,322	133	4.0	2,928	167	5.7	2,273	68	2.9	2,074	126	6.1
Kansas City Southern	2,248	115	5.1	2,408	260	10.8	1,411	81	5.0	1,784	118	6.6	914	66	7.2
Kentucky & Indiana Terminal	1,515	148	9.7												
Lake Erie & Western	660	31	4.6	798	66	8.2	502	35	6.9				90	2	2.2
Lake Shore & Michigan Southern	15,223	496	3.2	12,431	572	4.6	6,481	298	4.6	9,188	306	3.3	5,488	219	3.9
Lehigh Valley	11,541	472	4.0	8,845	306	3.4	6,985	218	3.1	5,806	121	2.0	2,526	77	3.0
Long Island	1,554	82	5.2												
Louisville & Nashville	15,248	552	3.6	15,307	661	4.3	11,274	554	4.9	4,794	139	2.9	4,035	154	3.8
Maine Central	2,155	152	7.0	2,437	210	8.6	1,755	97	5.5	1,801	32	1.7	1,856	43	2.3
Michigan Central	3,888	160	4.1	5,256	326	6.2	2,974	160	5.3	4,001	80	1.9	5,313	171	3.2
Minneapolis & St. Louis	2,782	287	10.3	2,710	473	17.4	1,282	160	12.4	1,328	114	8.5	1,043	74	7.0
Minneapolis, St. Paul & Sault Ste. Marie	7,792	431	5.5	6,378	626	9.8	2,101	194	9.2	5,641	551	9.7	3,712	387	10.4
Missouri, Kansas & Texas	7,048	415	5.8	6,079	584	9.6	4,004	491	12.2	2,808	179	6.3	2,020	170	8.4
Missouri, Kansas & Texas of Texas	1,360	68	5.0	967	64	6.6	679	67	9.8	2,713	131	4.8	1,218	59	4.8
Missouri Pacific	8,216	632	7.6	8,441	898	10.5	6,513	639	9.8	8,915	713	7.9	6,189	599	9.7
Mobile & Ohio	5,843	543	9.3	5,821	745	11.0	2,938	312	10.6	2,687	358	13.3	1,144	115	10.1
Morgan's Louisiana & Texas	803	15	1.8	894	38	4.2	372	30	8.0	528	6	1.1	172	2	1.1
Nashville, Chattanooga & St. Louis	3,019	113	3.7	4,843	186	3.8	1,597	75	4.7	1,671	38	2.2	1,181	31	2.6
New Orleans & North Eastern	4,042	369	9.1	3,702	445	12.0	1,724	200	11.6	904	92	10.1	745	77	10.3
New Orleans, Mobile & Chicago	778	59	7.6	849	94	10.6	427	22	5.1	537	52	9.6			
New Orleans Terminal Co.	809	50	6.1	765	84	8.3	601	23	3.8	409	31	7.5	370	44	11.8

New York Central & Hudson River	23,316	762	3.2	17,889	694	3.8	12,550	453	3.6	10,562	293	2.7	10,360	275	2.6
New York, Chicago & St. Louis	2,274	129	5.6	1,657	130	7.8	2,613	146	5.5	2,116	118	5.6	2,206	93	4.2
New York, New Haven & Hartford	20,813	1,296	6.2	14,307	1,382	9.6	7,377	428	5.8	6,641	235	3.5	4,083	117	2.9
New York, Ontario & Western	4,184	56	1.3	2,870	48	1.6	1,662	20	1.2	1,353	21	1.5	1,084	25	2.3
New York, Philadelphia & Norfolk	377	27	7.1	1,356	50	3.6	346	17	4.9	514	11	2.1	644	36	5.6
Norfolk & Western	7,751	204	2.6	8,188	212	2.5	6,771	191	2.8	9,334	168	1.8	8,429	203	2.4
Norfolk Southern	513	64	12.4	747	76	10.1	465	48	10.2	745	45	6.0	268	27	10.0
Northern Central	993	10	1.0												
Northern Pacific	15,925	941	5.9	14,549	1,373	9.4	11,896	652	5.4	12,118	803	6.6	10,829	710	6.5
Northern Pacific Terminal	1,030	15	1.4	198	4	2.0	774	20	2.5	526	2	.3	1,475	22	1.5
Oregon Short Line	7,023	211	3.0	5,143	386	7.5	3,285	204	6.2	5,018	135	2.6	4,973	163	3.3
Oregon-Washington Railroad & Navigation Co.	3,911	74	1.8	2,640	115	4.3	3,711	147	3.9	2,876	78	2.7			
Pennsylvania Co.	4,838	158	3.2	6,103	280	4.5	4,366	155	3.5	5,090	99	1.9	5,114	120	2.3
Pennsylvania Railroad	27,796	476	1.7	25,345	511	2.0	12,379	257	2.0	21,149	333	1.5	13,281	274	2.0
Peoria & Pekin Union	1,004	71	7.0												
Pere Marquette	3,557	368	10.3	5,414	647	11.9	2,104	203	9.6	2,008	171	8.5	4,440	302	6.8
Philadelphia & Reading	6,408	193	3.0	7,388	263	3.5	4,012	105	2.6	5,950	95	1.6	5,030	124	2.5
Pittsburgh & Lake Erie	1,174	44	3.7	1,744	91	5.2	648	24	3.7	2,380	84	3.5	1,199	79	6.6
Rutland	2,647	122	4.6	1,853	174	9.3	932	36	3.8	457	18	3.9	629	42	6.6
St. Louis & San Francisco	11,570	1,387	11.9	10,562	1,303	12.3	3,763	550	14.6	12,183	943	7.7	6,912	856	12.4
St. Louis, Brownsville & Mexico	233	19	8.1	1,081	133	12.2									
St. Louis, Iron Mountain & Southern	6,621	892	13.4	4,220	649	15.3	2,490	433	17.3	2,613	203	7.7	2,590	315	12.2
St. Louis Southwestern	2,509	143	5.7	1,303	136	10.4	797	77	9.6	585	21	3.6	744	67	9.0
San Antonio & Aransas Pass	2,211	74	3.3	2,313	153	6.6	1,381	106	7.6	932	41	4.4	543	38	7.0
San Pedro, Los Angeles & Salt Lake	4,118	94	2.2	2,850	85	2.9	1,601	86	5.3	2,407	44	1.8	1,733	42	2.4
Seaboard Air Line	9,392	1,003	10.6	6,906	698	10.1	4,057	284	7.0	2,868	132	4.6	3,756	334	8.9
Southern	21,497	1,644	7.6	22,466	1,793	7.9	11,842	879	7.4	14,693	680	4.6	12,121	654	5.4
Southern Railway in Mississippi	1,074	130	12.1	1,122	148	13.1	121	10	8.2	60	10	16.6	35	3	8.5
Southern Pacific	25,121	622	2.4	24,633	978	3.9	17,318	809	4.6	14,984	322	2.1	20,672	480	2.3
Spokane, Portland & Seattle	1,575	26	1.6	1,454	54	3.7	741	18	2.4	937	29	3.1	1,564	96	6.1
Tennessee Central	187	11	5.8	864	84	9.7	545	46	8.4	204	17	8.3	238	9	3.7
Terminal Railroad Association of St. Louis	3,107	455	14.6	710	109	15.3	527	47	8.9	707	58	8.2	455	61	13.4
Texas & New Orleans	1,642	45	2.7	1,105	79	7.1	501	29	5.7	613	27	4.4			
Texas & Pacific	4,451	196	4.4	4,437	238	5.3	3,035	259	8.5	3,621	171	4.7	1,727	83	4.8
Toledo & Ohio Central	1,723	127	7.3	1,395	123	8.8	627	43	6.8	348	29	8.3			
Union Pacific	15,975	181	1.1	14,732	408	2.8	14,481	1,031	7.1	10,707	180	1.6	11,984	300	2.5
Union Railway (Memphis)	1,193	185	15.5												
Union Stock Yards Co. of Omaha	1,249	19	1.5	980	15	1.5	469	27	5.7	439	4	.9	736	40	5.4
Virginian	1,915	61	3.1	2,315	36	1.5	1,320	22	1.6	2,036	31	1.5	1,936	96	4.9
Wabash	9,266	860	9.2	8,824	972	11.0	6,403	762	11.9	6,826	531	7.7	6,569	727	11.0
Washington Southern	1,525	41	2.6	994	36	3.1	1,003	15	1.4	728	24	3.3	180	21	11.6
Western & Atlantic	519	29	5.5	989	59	5.9									
Western Maryland	2,633	142	5.3	1,798	57	3.1	1,330	57	4.2	2,851	84	2.9	1,472	51	3.5
Western of Alabama	2,091	103	4.9	1,628	118	7.2	803	31	3.8	570	24	4.2	377	8	2.1
Western Pacific	2,209	71	3.2	3,798	112	2.9	2,315	105	4.5	1,352	108	7.9	198	21	10.6
West Shore	2,591	127	4.9	933	56	6.0	412	20	4.8	383	4	1.0	800	32	4.0
Wheeling & Lake Erie	822	47	5.7	598	41	6.8	453	31	6.8	565	23	4.1	715	22	3.1
Yazoo & Mississippi Valley	4,473	541	12.0	2,727	493	18.0	610	85	13.9	303	29	9.5	1,005	111	11.0

TABLE No. 5.—*Showing the amounts of penalties (exclusive of costs) paid by the variou carriers for violations of the safety-appliance, hours-of-service, and ash-pan acts, as reported by the Solicitor for the Treasury Department prior to Oct. 1, 1914.*

Name of railroad.	Safety-appliance act.	Hours-of-service act.				Ash-pan act.	Combined totals.
		Trainmen.	Telegraph operators.	Failure to report.	Total.		
Aberdeen & Rockfish	$300						$300.00
Alabama & Vicksburg	100						100.00
Alabama Great Southern	1,000						1,000.00
Alabama, Tennessee & Northern	200						200.00
Ann Arbor	300						300.00
Apalachicola Northern	100						100.00
Arizona & New Mexico	400						400.00
Ashland Coal & Iron	700						700.00
Atchison, Topeka & Santa Fe	7,900	$15,125.00			$15,125.00		23,025.00
Atlanta Terminal	100						100.00
Atlanta & St. Lawrence	500						500.00
Atlantic Coast Line	13,200		$1,400		1,400.00		14,600.00
Baltimore & Ohio Chicago Terminal	3,100						3,100.00
Baltimore & Ohio	14,300	7,220.00	685	$3,100	11,005.00		25,305.00
Baltimore & Ohio Southwestern	1,500	825.00			825.00		2,325.00
Bangor & Aroostook	400						400.00
Bellingham Bay & British Columbia	200						200.00
Belt Railway of Chicago	1,300					$600	1,900.00
Bessemer & Lake Erie	200						200.00
Blue Ridge	400					200	600.00
Boston & Albany	600						600.00
Boston & Maine	2,400	2,850.00	250		3,100.00	200	5,700.00
Boyne City, Gaylord & Alpena	300						300.00
Buffalo & Susquehanna	700						700.00
Buffalo, Rochester & Pittsburg	1,700						1,700.00
Butte, Anaconda & Pacific	100						100.00
Butte County	500						500.00
Canadian Pacific	200			500	500.00		700.00
Cape Girardeau & Chester	600						600.00
Carolina, Clinchfield & Ohio	100						100.00
Central New England	100	1,600.00			1,600.00		1,700.00
Central of Georgia	800	1,400.00			1,400.00		2,200.00
Central Railroad of New Jersey	1,900		200		200.00		2,100.00
Central Railroad of Pennsylvania	100						100.00
Central Vermont	3,700	6,075.00		3,000	9,075.00	200	12,975.00
Charleston & Western Carolina	100						100.00
Chesapeake & Ohio	10,400	2,185.00		1,000	3,185.00		13,585.00
Chesapeake & Ohio of Indiana	300	1,850.00			1,850.00		2,150.00
Chesapeake Beach	100						100.00
Chicago & Alton	2,200	2,200.00	175		2,375.00	400	4,975.00
Chicago & Eastern Illinois	1,300	9,500.00		1,500	11,000.00		12,300.00
Chicago & Erie	700						700.00
Chicago & Northwestern	7,300	100.00	50		150.00		7,450.00
Chicago & South Bend	100						100.00
Chicago & Western Indiana	100						100.00
Chicago, Burlington & Quincy	6,900	2,400.00	300	300	3,000.00		9,900.00
Chicago, Det. & Can. Grand T. Junc.	1,400						1,400.00
Chicago Great Western	1,800	2,685.00	310		2,995.00		4,795.00
Chicago, Indianapolis & Louisville	1,100	725.00	1,400	500	2,625.00	400	4,125.00
Chicago Junction	100						100.00
Chicago, Memphis & Gulf	300						300.00
Chicago, Milwaukee & Puget Sound	100	6,250.00		500	6,750.00		6,850.00
Chicago, Milwaukee & St. Paul	4,400	1,996.00	775	5,300	8,071.00		12,471.00
Chicago, Peoria & St. Louis	200	50.00	50		100.00		300.00
Chicago, Rock Island & El Paso	100						100.00
Chicago, Rock Island & Gulf	100						100.00
Chicago, Rock Island & Pacific	7,100	3,975.00	600	1,100	5,675.00	200	12,975.00
Chicago, St. P., Minneap. & Omaha	300	.96			.96		300.96
Chicago Terminal Transfer	100						100.00
Cincinnati, Bluffton & Chicago	100					200	300.00
Cincinnati, Hamilton & Dayton	2,200	1,050.00	25		1,075.00		3,275.00
Cincinnati Northern	100						100.00
Cincinnati, New Orleans & Tex. P.	1,100		500		500.00		1,600.00
Cincinnati, Saginaw & Mackinaw	100						100.00
Cleveland, Cin., Chicago & St. Louis	8,800	5,015.00	800		5,815.00		14,615.00
Cleveland, Lorain & Wheeling	100						100.00
Coal & Coke	600						600.00
Colorado & Northwestern	200						200.00
Colorado & Southern	900	3,900.00	1,000	3,000	7,900.00		8,800.00
Columbia & Puget Sound	100						100.00
Colorado Midland	1,100	250.00			250.00		1,350.00
Copper Range	400						400.00
Corvallis & Eastern	100						100.00
Coudersport & Port Allegheny	500						500.00

TABLE No. 5.—*Showing the amounts of penalties (exclusive of costs) paid by the various carriers for violations of the safety-appliance, hours-of-service, and ash-pan acts, as reported by the Solicitor for the Treasury Department prior to Oct. 1, 1914*—Continued.

Name of railroad.	Safety-appliance act.	Hours-of-service act.				Ash-pan act.	Combined totals.
		Trainmen.	Telegraph operators.	Failure to report.	Total.		
Covington & Cin. Elev. R. & T. & B.	$300						$300.00
Cumberland Valley	100						100.00
Danville & Western	100						100.00
Dayton & Union	300						300.00
Delaware & Hudson	5,500	$300.00			$300.00		5,800.00
Delaware, Lackawanna & Western	400						400.00
Denver & Rio Grande	5,400	4,400.00	$675		5,075.00		10,475.00
Detroit & Toledo Shore Line	500						500.00
Detroit, Grand Haven & Milwaukee	100						100.00
Detroit, Toledo & Ironton	1,200	650.00		$3,000	3,650.00		4,850.00
Duluth, Missabe & Northern	200	60.00			60.00		260.00
Duluth, Rainy Lake & Winnipeg	200						200.00
Duluth, South Shore & Atlantic	800						800.00
Duluth, Union Depot & Transfer	100						100.00
Eagles Mere	100						100.00
East Jordan & Southern	300						300.00
Elgin, Joliet & Eastern	300						300.00
El Paso & Southwestern	1,800						1,800.00
El Paso & Southwestern of Texas	400						400.00
Erie	11,800	5,000.00			5,000.00		16,800.00
Escanaba & Lake Superior	400					$200	600.00
Evansville & Terre Haute	300						300.00
Florida East Coast	300						300.00
Fort Smith & Western		200.00			200.00		200.00
Fort Worth & Denver City	600						600.00
Gainesville Midland	100						100.00
Galveston, Harrisb. & San Antonio	700	200.00			200.00		900.00
Galveston, Houston & Henderson	200						200.00
Georgia, Florida & Alabama	400						400.00
Georgia, Southern & Florida	100						100.00
Grand Rapids & Indiana		2,025.00			2,025.00		2,025.00
Grand Trunk Ry. of Canada	2,500						2,500.00
Grand Trunk Western	2,600	1,000.00		3,000	4,000.00		6,600.00
Great Northern	12,600	3,240.00	317	1,000	4,557.00		17,157.00
Green Bay & Western	100						100.00
Gulf, Colorado & Santa Fe	2,100		800		800.00		2,900.00
Gulf & Ship Island	200						200.00
Hines Bros. Lumber Co	200						200.00
Hocking Valley	600	1,500.00			1,500.00		2,100.00
Houston & Texas Central	1,800	500.00		3,000	3,500.00		5,300.00
Houston Belt & Terminal Co	200		400		400.00		600.00
Idaho Northern	200						200.00
Illinois Central	17,400	11,340.00		1,800	13,140.00		30,540.00
Illinois Northern	100						100.00
Illinois Southern	200	150.00			150.00		350.00
Indiana Harbor	100						100.00
Indiana Harbor Belt	200	575.00			575.00		775.00
Indiana Northern	100						100.00
International & Great Northern	1,600						1,600.00
Iowa Central	1,000	1,750.00			1,750.00		2,750.00
Jonesboro. Lake City & Eastern	350					400	750.00
Kanawha & Michigan		1,000.00		3,000	4,000.00		4,000.00
Kansas City, Mexico & Orient		100.00			100.00		100.00
Kansas City Southern	1,900	1,650.00	325		1,975.00		3,875.00
Kentucky & Indiana Bridge	300						300.00
Kentucky & Indiana Terminal	700						700.00
Keweenaw Central	400					200	600.00
Lake Charles & Northern	200						200.00
Lake Erie & Western	200						200.00
Lake Shore & Michigan Southern	1,500	1,000.00	1,000		2,000.00		3,500.00
Lake Superior & Ishpeming	100						100.00
Lake Superior Terminal & Transfer	100						100.00
Lehigh & Hudson	200						200.00
Lehigh Valley	1,000	350.00	50		400.00		1,400.00
Lewisburg & Ronceverte	200						200.00
Live Oak, Perry & Gulf	200						200.00
Louisiana & Arkansas	200						200.00
Louisiana & Northwest						400	400.00
Louisiana & Pacific	100						100.00
Louisiana Railway & Navigation	1,000	300.00			300.00		1,300.00
Louisiana Western	400						400.00
Louisville & Jeffersonville Bridge	100						100.00
Louisville & Nashville	3,400	3,025.00	1,525		4,550.00		7,950.00

TABLE NO. 5.—*Showing the amounts of penalties (exclusive of costs) paid by the various carriers for violations of the safety-appliance, hours-of-service, and ash-pan acts, as reported by the Solicitor for the Treasury Department prior to Oct. 1, 1914*—Continued.

Name of railroad.	Safety-appliance act.	Hours-of-service act				Ash-pan act.	Combined totals.
		Trainmen.	Telegraph operators.	Failure to report.	Total.		
Louisville, Henderson & St. Louis	$500						$500.00
Maine Central	600						600.00
Manistee & Grand Rapids						$200	200.00
Manistique & Lake Superior	100					200	300.00
Maryland Electric Railways	200						200.00
Memphis, Dallas & Gulf	400						400.00
Michigan Central	1,900						1,900.00
Midland Valley	200	$25.00			$25.00		225.00
Minneapolis & St. Louis	800	820.00	$725		1,545.00		2,345.00
Minneapolis, St. Paul & S. Ste. Marie	300	1,530.18	1,400	$3,000	5,930.18		6,230.18
Minnesota & International	200	100.00			100.00		300.00
Minnesota Transfer	800						800.00
Mississippi Central	300						300.00
Missouri, Kansas & Texas	600	875.00	3,500	3,000	7,375.00		7,975.00
Missouri, Kansas & Texas of Texas	2,000	2,925.00	1,600	3,000	7,525.00		9,525.00
Missouri & North Arkansas		430.00		200	630.00		630.00
Missouri, Oklahoma & Gulf		2,500.00			2,500.00		2,500.00
Missouri, Oklahoma & Gulf of Texas		500.00			500.00	200	700.00
Missouri Pacific	4,500	5,055.00	640		5,695.00		10,195.00
Mobile & Ohio	6,100					200	6,300.00
Montpelier & Wells River	100						100.00
Morgans' La. & Tex. R. & S. Co	200						200.00
Morristown & Erie	100						100.00
Muscatine North & South	200						200.00
Nashville, Chattanooga & St. Louis	400	1,150.00			1,150.00		1,550.00
National City & Otay	200						200.00
Nevada-California-Oregon	800	400.00			400.00		1,200.00
Nevada Central	300						300.00
Nevada County Narrow Gauge	700						700.00
New Jersey, Indiana & Illinois	100						100.00
New Orleans & Northeastern	2,000						2,000.00
New Orleans Great Northern	1,000						1,000.00
New Orleans, Mobile & Chicago		625.00			625.00		625.00
New Orleans Public Belt	400						400.00
New York Central & Hudson River	1,300	7,000.00			7,000.00		8,300.00
New York, Chicago & St. Louis	300						300.00
New York, New Haven & Hartford	2,200	4,300.00	2,700		7,000.00		9,200.00
New York, Philadelphia & Norfolk	400						400.00
Norfolk & Portsmouth Belt Line	300						300.00
Norfolk & Southern	200	100.00			100.00		300.00
Norfolk & Western	5,300	500.00			500.00		5,800.00
Northern Pacific	19,500	2,600.00	600	1,200	4,400.00		23,900.00
Northern Pacific Terminal of Oreg	800						800.00
Northwestern Pacific	1,100						1,100.00
Oklahoma Central		360.00			360.00		360.00
Oregon, Washington R. R. & Nav	900	1,150.00	100		1,250.00		2,150.00
Oregon Short Line	3,000	1,050.00		3,000	4,050.00		7,050.00
Pacific Coast	2,500						2,500.00
Paris & Great Northern		600.00			600.00		600.00
Pecos & Northern Texas		300.00			300.00		300.00
Pennsylvania Railroad	2,700						2,700.00
Pere Marquette	3,600	700.00			700.00		4,300.00
Philadelphia & Reading	1,500						1,500.00
Pickens	100						100.00
Pittsburgh & Lake Erie	900						900.00
Pittsburgh, Cincinnati, C. & St. L	500	1,750.00	1,050		2,800.00		3,300.00
Pennsylvania Co	400	5,200.00			5,200.00		5,600.00
Quincy, Omaha & Kansas City		625.00			625.00		625.00
Rapid City, Black Hills & Western	200						200.00
Reynoldsville & Falls Creek	200						200.00
Richm'd, Fredericksb'g & Potomac	300						300.00
Rio Grande & El Paso	300						300.00
Rio Grande & Pagosa Springs	100						100.00
Rio Grande Western	500						500.00
Rutland	400	50.00			50.00		450.00
St. Clair Tunnel Co	400						400.00
St. Johns River Terminal Co	100						100.00
St. Joseph & Grand Island		100.00			100.00		100.00
St. Louis & Hannibal		290.00			290.00		290.00
St. Louis & San Francisco	5,000	900.00	800		1,700.00		6,700.00
St. Louis, Iron Mountain & Southern	10,400	1,210.00	360		1,570.00		11,970.00
St. Louis Southwestern	1,900	150.00	260		410.00		2,310.00
St. Louis Southwestern of Texas	800	475.00	1,100		1,575.00		2,375.00

TABLE No. 5.—*Showing the amounts of penalties (exclusive of costs) paid by the various carriers for violations of the safety-appliance, hours-of-service, and ash-pan acts, as reported by the Solicitor for the Treasury Department prior to Oct. 1, 1914*—Continued.

Name of railroad.	Safety-appliance act.	Hours-of-service act.				Ash-pan act.	Combined totals.
		Trainmen.	Telegraph operators.	Failure to report.	Total.		
St. Louis Transfer	$100						$100.00
St. Louis, Vandalia & Terra Haute	200						200.00
St. Louis, Watkins & Gulf	600						600.00
St. Paul & Kansas City Short Line		$75.00			$75.00		75.00
Salt Lake & Los Angeles	300					$200	500.00
San Antonio & Aransas Pass			$350		350.00		350.00
San Pedro, Los Angeles & Salt Lake	1,400	700.00	300		1,000.00		2,400.00
Seaboard Air Line	2,700	2,350.00			2,350.00		5,050.00
South Dakota Central	300						300.00
Southern Kansas of Texas	100						100.00
Southern Pacific	5,300	770.00			770.00		6,070.00
Southern	14,800	3,700.00			3,700.00	400	18,900.00
Southern in Mississippi	1,100						1,100.00
Spokane & International		100.00			100.00		100.00
Spokane, Portland & Seattle	100						100.00
Sumpter Valley	400						400.00
Susquehanna & New York	100						100.00
Susquehanna, Bloomsb'g & Berwick	200						200.00
Takoma Eastern			100		100.00		100.00
Tampa & Jacksonville	100						100.00
Tennessee Central	100						100.00
Terminal Railroad Asso. of St. Louis	2,500						2,500.00
Texarkana & Fort Smith	400						400.00
Texas & New Orleans	1,000						1,000.00
Texas & Pacific	2,100						2,100.00
Texas Central		10.00			10.00		10.00
Texas Mexican	800						800.00
Texas Midland	200						200.00
Toledo & Ohio Central	800	400.00	25		425.00		1,225.00
Toledo, Columbus & Ohio River	100						100.00
Toledo Terminal & Ry. Co	100						100.00
Toledo, St. Louis & Western	200	400.00	10		410.00		610.00
Tombigbee Valley	500						500.00
Tremont & Gulf	300					400	700.00
Trinity & Brazos Valley	600						600.00
Tuscarora Valley	200						200.00
Union Depot Co. (Columbus, Ohio)			600		600.00		600.00
Union Pacific	3,600	1,275.00		$2,000	3,275.00		6,875.00
Union (Memphis, Tenn.)	500						500.00
Union Stock Yards	200						200.00
Vandalia	100	325.00			325.00		425.00
Vicksburg, Shreveport & Pacific	300						300.00
Wabash	8,000	3,070.00	125	2,000	5,195.00	200	13,395.00
Washington & Columbia River	300						300.00
Washington & Vandemere	200						200.00
Washington Southern	100						100.00
Western & Atlantic	100	500.00	100		600.00		700.00
Western Maryland	200	2,850.00			2,850.00		3,050.00
Western Pacific	300		300		300.00		600.00
Western Ry. of Alabama	200						200.00
Wheeling & Lake Erie	300						300.00
White River						200	200.00
Wichita Falls & Northwestern		3,000.00			3,000.00		3,000.00
Wichita Falls & Northw'n of Texas	100	200.00			200.00		300.00
Wiggins Ferry	400						400.00
Wisconsin & Northern	300					200	500.00
Wisconsin Central	500						500.00
Yazoo & Mississippi Valley	6,700	2,725.00		600	3,325.00		10,025.00
Total	366,550	188,337.14	30,357	52,600	271,294.14	6,000	643,844.14

EXTRACTS FROM THE TWENTY-EIGHTH ANNUAL REPORT OF THE INTERSTATE COMMERCE COMMISSION PERTAINING TO THE WORK OF THE DIVISION OF SAFETY.

SAFETY-APPLIANCE ACTS.

During the fiscal year ended June 30, 1914, 171 employees were killed and 2,694 injured in the coupling and uncoupling of cars. The corresponding figures for the two preceding years were 192 deaths and 3,236 injuries in 1912 and 195 deaths and 3,361 injuries in 1913. Casualties resulting from overhead and side obstructions and from falling from and getting on and off cars occasioned during the past fiscal year 643 deaths and 16,428 injuries to employees. These figures for the year ended June 30, 1912, were 704 deaths and 15,721 injuries; and for the year 1913, 721 deaths and 18,257 injuries.

During the fiscal year 257 cases, involving an aggregate of 1,020 violations of the safety-appliance acts, were transmitted to the several United States attorneys for prosecution. Cases comprising 149 counts were tried in court, of which 121 counts were decided in favor of the Government. Cases involving 43 counts were argued in the Circuit Courts of Appeals, 17 of which were decided in favor of the Government and 26 for the defendant. The decisions of the Circuit Court of Appeals on these 26 counts will be taken to the Supreme Court on writ of error. Carriers confessed judgment during the year as to 483 counts. Penalties aggregating $78,700 were assessed.

In its annual reports for 1912 and 1913 the Commission adverted to the insufficiency of inspection by the carriers in certain instances at terminals and repair points. From the number of violations reported for prosecution it is evident that cars continue to be moved away from repair points in a defective condition, when slight repairs would render them conformable to the statute. The need of adequate repair facilities at all essential points is obvious, and the desirability of carriers requiring from responsible employees at such points a working knowledge of the safety-appliance acts and of the orders of the Commission can not be too strongly emphasized.

The period in which equipment other than freight cars was to have been made conformable to the standards fixed by the Commission's order of March 13, 1911, pursuant to the act of April 14, 1910, has now expired, and conditions generally in this respect are satisfactory.

As to freight cars, however, the number equipped as compared with the number to be equipped is disproportionately small, and only the exercise of the greatest diligence will enable the carriers to standardize their freight equipment within the interval that yet remains.

The Commission has caused to be prepared and issued as a public document a Digest of Decisions published prior to October 1, 1914, in which the Federal safety-appliance and hours-of-service acts have been construed.

JUDICIAL INTERPRETATION OF THE SAFETY-APPLIANCE ACTS.

Since the publication of the last annual report the Supreme Court has affirmed the decision of the Circuit Court of Appeals for the Third Circuit, 203 Fed., 681, to the effect that the safety-appliance acts do not require automatic couplers between locomotives and tenders. *Pennell* v. *Philadelphia & Reading Railway Co.*, 231 U. S., 675.

In *Southern Railway Co.* v. *Crockett*, 234 U. S., 725, it was held that by the amendment of 1903 the standard height of drawbars was made applicable to locomotive engines as well as to freight cars.

In *Spokane & I. E. R. Co.* v. *United States*, 210 Fed., 243, the Circuit Court of Appeals for the Ninth Circuit, affirming the judgment of the District Court for the Eastern District of Washington, held that the words "used on street railways," as employed in the act of 1893, exempting such cars from the operation of the statute, do not include cars of an interurban line engaged in interstate commerce, even though they may be run for a short distance over the street railway tracks in order to reach a terminal in the center of a city.

In *Chicago, Burlington & Quincy Rail Road Co.* v. *United States*, 211 Fed., 12, the Circuit Court of Appeals for the Eighth Circuit held that the provisions of the safety-appliance acts, other than those relating to air-brake equipment, apply to switching operations; that the movement of a car with an inoperative coupler is not excused by the operative condition of the coupler on an adjacent car to which it is connected and from which it may be uncoupled by means of the lever on such adjacent car; and that a carrier in order to bring itself within the proviso in the act of April 14, 1910, so as to justify its movement of a defective car "to the nearest available point" where such car might be repaired, must show not only that the repairs could not have been made where the defects were discovered, but that the movement of the car was for the purpose of repair. It was further held, however, in this case that the air-brake provisions of the act do not apply to switching operations, and that the movement by a switching crew of a string of cars from one terminal yard to another in the same city for distribution into outgoing trains was a switching operation, notwithstanding the distance between the yards was two miles, and the cars were moved over a main-line track used also by other roads. On petition of the Government a writ of certiorari to the Supreme Court has been granted upon the air-brake question involved in this decision.

To the same effect is the decision in *United States* v. *Erie Railroad Co.*, 212 Fed., 853, wherein the Circuit Court of Appeals for the Third Circuit reiterates its conclusion previously announced in 197 Fed., 287, that the air-brake provisions of the act were not intended to apply to intraterminal or switching movements. A writ of error has been filed to take this case to the Supreme Court.

A decision directly opposed to the two last cited, in so far as those cases relate to the air-brake provision of the act, however, was announced in *United States* v. *Atlantic Coast Line Railroad Co.*, 214 Fed., 498, in which the District Court for the Southern District of Florida held that the provisions of the act apply no less to switching movements than to main-line operations. And a similar conclusion was reached by the Supreme Court of Minnesota, after full consideration of all the cases on this subject, in the case of *La Mere* v. *Railway Transfer Co. of Minneapolis*, 145 N. W., 1068.

In *United States* v. *Chesapeake & Ohio Railway Co.*, 213 Fed., 748, the Circuit Court of Appeals for the Fourth Circuit, construing the proviso in the act of 1910, held that where a car was equipped at the inception of its journey as contemplated by the statute and thereafter found to be defective, it was incumbent upon the carrier to repair such defect as soon as the services of a repair man could be had, provided such defects were remediable at the point of discovery; that otherwise such defective car might have been hauled to the nearest available point where such defects might have been repaired, but not used in the meantime on the lines of the carrier between stations or in its yards.

In the case of *United States* v. *Trinity & Brazos Valley Railway Co.*, 211 Fed., 448, the Circuit Court of Appeals for the Fifth Circuit held that a carrier, in order to justify the movement of a defective car under the proviso in the act of 1910, must show that such car was properly equipped when it started on its journey and that it became defective while in use on such carrier's road; and that where the movement of a car was continued in a train in commercial use after such car had become defective, the carrier to be relieved of liability must show that such movement was necessary in order to reach the nearest point where the defects involved might be repaired.

In two unreported cases against the Northern Pacific Railway Co., decided December 5–6, 1913, by the District Court for the Western District of Washington, the jury was instructed that efficiency of a hand brake comprehends its efficiency for the purpose of stopping or holding a car or train as well as its efficiency as a matter of safety to employees engaged in work requiring the use of the hand brake; that the "nearest available point," as used in the act, means the nearest available point for making repairs of the kind the particular car in question needs; that the act prohibits the movement of a car by means of chains instead of drawbars, unless such car contains live stock or perishable freight, beyond the nearest point where it may be diverted from the main-line track; and that unless such car is repaired at such point of diversion it can be hauled to a repair point only in a nonrevenue train and dissociated from cars commercially used. The jury was also instructed that a carrier, in order to justify the movement of a defective car under the proviso in the act of 1910, must establish the necessity of such movement for the purpose of repair, and the fact that such repairs could not have been made except at such repair point.

ASH-PAN ACT.

During the fiscal year ended June 30, 1914, three cases involving three violations of the ash-pan act were transmitted by the Commission for prosecution, and defendants confessed judgment as to three counts. Penalties in the sum of $1,600 were assessed.

Practically all locomotives subject to the ash-pan act have been equipped as contemplated by the statute, and the principal duty now devolving upon the carriers in this respect is to maintain in an operative condition the devices already installed.

HOURS-OF-SERVICE ACT.

During the fiscal year ended June 30, 1914, 233 cases, involving an aggregate of 2,871 violations of the hours-of-service act, were transmitted to the several United States attorneys for prosecution. During the same period the carriers confessed judgment as to 1,785 counts. Of the 592 counts which went to trial, 395 resulted in favor of and 164 adversely to the Government, and 33 are still pending decision. Of the cases originally decided in favor of defendants, 34 counts have been appealed by the Government, and 38 of the 395 counts originally decided in favor of the Government have been appealed by defendants. Of 121 counts argued in the Circuit Courts of Appeals 98 were decided in favor of the Government. Penalties aggregating $162,422 were assessed.

The analysis of carriers' monthly hours-of-service reports, exhibiting the number of instances and the causes of excess service, as described in the last annual report of the Commission, has been continued through the past fiscal year, and the summaries developed show a marked reduction in the volume of excess service.

During the fiscal year 1,194 railroads filed complete reports. Of these, 739 certified each month under oath that no excess service has occurred on their respective lines. The remaining 455 carriers reported an aggregate of all classes of excess service of 165,305 instances in which employees were on duty for longer periods than those permitted by the statute.

The published tables show an aggregate of all classes of excess service reported during the year of 163,192 cases, a reduction of 136,761 instances from those exhibited by the summaries for 1913. The number of instances reported during the past fiscal year, however, appears to be still unduly large, particularly those caused by hot boxes, defective couplers, and miscellaneous car defects, and it is suggested that a more rigid inspection of equipment at terminals and repair points by the carriers would effect a substantial diminution in the number of reportable cases.

Attention is again directed to the diversity of opinion in the various courts as to the proper penalties to be assessed for violations of the hours-of-service act. A bill is now pending in Congress which, if passed, should remedy this situation.

Attention is also directed to the considerable number of instances of excess service attributed to "broken drawbars," "leaky flues," "hot boxes," and other circumstances ordinarily to be expected in the operation of trains, and the Commission respectfully renews its former recommendation that the proviso in section 3 of the hours-of-service act be so amended as clearly and specifically to define the causes which shall excuse the carriers' retention of employees on duty for periods longer than those prescribed, and the extent to which such retention shall be justified.

JUDICIAL INTERPRETATION OF THE HOURS-OF-SERVICE ACT.

In *Missouri, Kansas & Texas Railway Co., of Texas* v. *United States*, 231 U. S., 112, it was held that where several employees are required to render service in excess of that permitted by the hours-of-service act, even though the detention of all may be attributable to a single cause, a separate penalty is incurred as to each employee so detained; and that an employee, subject to call, waiting for a train to move, and not permitted to go away, is on duty within the meaning of the act. It was also held that the penalty assessable under the hours-of-service act is determinable by the court and not by the jury.

In *United States* v. *Southern Pacific Co.*, 209 Fed., 562, the Circuit Court of Appeals for the Eighth Circuit, affirming the decision of the District Court for the District of Utah, held that while sudden illness might not in all cases constitute an emergency within the meaning of the act, the sudden illness of one of three regular train dispatchers, supplemented by the inability of the company to procure a substitute, excused the retention on duty of the two remaining train dispatchers for periods in excess of 9 hours out of 24. It was also held that the word "week," as used in the statute, means any period of seven days, and is not restricted to a calendar week.

In *United States* v. *Missouri Pacific Railway Co.*, 213 Fed., 169, the Circuit Court of Appeals for the Eighth Circuit, affirming the judgment of the District Court for the District of Kansas, held that the defendant was justified in requiring an operator in a day office to remain on duty for a longer period than that ordinarily permitted by the statute, where the excess service was occasioned by the necessity of detouring trains around a wreck resulting from an unavoidable accident.

In *Missouri Pacific Railway Co.* v. *United States*, 211 Fed., 893, the Circuit Court of Appeals for the Eighth Circuit reversed the judgment rendered by the District Court for the Western District of Missouri and directed a new trial. The appellate court held that the act does not apply to switch tenders charged merely with the duty of operating signals and switches in accordance with orders received by telephone.

The case of *United States* v. *Atlantic Coast Line Railroad Co.*, decided by the District Court for the District of South Carolina, was reversed by the Circuit Court of Appeals for the Fourth Circuit in *United States* v. *Atlantic Coast Line Railroad Co.*, 211 Fed., 897. The appellate court held that no distinction is to be drawn between offices in which train orders originate and from which they are issued, and local offices which merely receive and deliver the orders so issued, and which may be open during the daytime and a substantial portion of the night in each 24-hour period; hence, where a local telegraph office was regularly kept open for business from 6.30 a. m. to 10.15 p. m. in each 24-hour period, it was an office continuously operated night and day and fell, therefore, within the 9-hour provisions of the act.

In an unreported case against the Northern Pacific Railway Co., decided February 13, 1914, by the District Court for the Western District of Washington, it was held that an employee goes on duty, within the meaning of the hours-of-service act, when he reports for work, and that he so remains on duty until he reaches the end of his run, or until he is relieved from all service or responsibility in connection with his train, and is given an unqualified, bona fide release for a definite and substantial period. And in *United States* v. *Northern Pacific Railway Co.*, 213 Fed., 539, the District Court for the Eastern District of Washington ruled that a definite and predetermined intermission of 1 hour and 30 minutes, during which a train crew waited for superior trains to meet and pass, did not break the continuity of service of such employees.

In *San Pedro, Los Angeles & Salt Lake Railroad Co.* v. *United States*, 213 Fed., 326, the decision of the District Court for the District of Utah, to the effect that requiring or permitting a fireman who has been on duty as such for 16 hours and is thereafter required to watch an engine is a violation of the hours-of-service act, was affirmed by the Circuit Court of Appeals for the Eighth Circuit. Similar decisions were sustained by the Circuit Court of Appeals for the Ninth Circuit in *Great Northern Railway Co.* v. *United States*, 211 Fed., 309, and *Northern Pacific Railway Co.* v. *United States*, 213 Fed., 577.

The District Court for the Western District of South Carolina, on October 30, 1913, in a case against the Southern Railway, unreported, held that the occurrence of a delay occasioned by an act of God, a casualty or an unavoidable accident, while a train was in course of transit from one terminal to another, did not suspend the act as to that train; but that its application was suspended only so far as might have been necessary to permit the crew to reach a point at which, with due regard to all the circumstances, the crew might have been relieved, or have had an opportunity to take the rest intended by the statute.

But in *United States* v. *Atchison, Topeka & Santa Fe Railway Co.*, 212 Fed., 1000, the District Court for the District of Arizona held that where a passenger train was delayed by the derailment of a freight train, after the crew had left its starting point, the company was not bound to tie up the train at the first stopping place where its crew could have been replaced, but was entitled without incurring liability to operate the train to the end of the passenger crew's run, the word "terminal" as used in the act being synonymous with "the end of the run" of the particular crew involved. It was further held, however, that where an interstate revenue train was delayed by the hauling, in violation of the safety-appliance act, of a car containing neither live stock nor perishable freight, by means of a chain, after its drawhead had become broken, the delay was not the result of a casualty or unavoidable accident within the proviso in the hours-of-service act.

In *United States* v. *Oregon-Washington Railroad & Navigation Co.*, 213 Fed., 688, the District Court for the Eastern District of Washington held that the duty of carriers under the act is absolute; that the word "permit" as used in the statute means "a failure to prohibit by one who has the power and authority to do so;" and that the defendant could not plead as a defense to an action for the penalty provided by the act the fact that the excess service involved had been performed without its knowledge and against its positive directions.

In *Northern Pacific Railway Co.* v. *United States*, 213 Fed., 162, the Circuit Court of Appeals for the Eighth Circuit held that the omission by a carrier from its hours-of-service report, submitted in good faith and within the period prescribed therefor by the Commission's order of June 28, 1911, of one or more instances of excess service that should have been reported, or any mistake of law or fact made in good faith therein, does not subject such carrier to the penalties or forfeitures prescribed by section 20 of the act to regulate commerce.

But in an unreported case against the Oregon-Washington Railroad & Navigation Co., decided April 20, 1914, by the District Court for the Eastern District of Washington, based upon the failure of defendant to report to the Commission as required by its order of June 28, 1911, certain instances of excess service, the carrier relied entirely, as a defense, upon the fact that the Commission had not attached to or included with the order as served upon the defendant certain " accompanying forms " therein described. Forms concededly identical, however, with those in issue had been employed by the carrier in the preparation of reports submitted for the months in which the instances omitted had occurred. The court held that the requirement of service of the order rested entirely on the terms of the order itself; that service of the order was intended for no other purpose than to impart notice to the carriers affected by it; that defendant had full notice of the order and of its requirements, and full opportunity to comply with its provisions, and that the most formal service could have accomplished nothing more than this. The contention of defendant was accordingly denied.

INVESTIGATION OF ACCIDENTS.

Sixty-three train accidents were investigated by the Commission during the year ended June 30, 1914. Forty of these accidents were collisions and 23 were derailments. They caused the death of 169 and the injury of 2,134 persons. The collisions investigated were responsible for 108 deaths and 1,162 injuries and the derailments caused 61 deaths and 972 injuries. Thirteen of these collisions, causing 39 deaths and 442 injuries, occurred where the block system was in use, and 24 collisions, involving 64 deaths and 713 injuries, occurred under the train-order system. Three collisions, causing 5 deaths and 7 injuries, occurred in yard movements where the system of train operation was not a factor.

Collisions caused by improper flagging continue to be a prominent feature of these investigations. Eight of the 40 collisions investigated were due to this cause. In these 8 collisions 45 persons were killed and 386 injured. Attention has been called to the indefiniteness of the flagging rule in force on many roads, and the practice of employing inexperienced men as flagmen. A noticeable effort has been made on a number of roads to improve the situation in this respect, but there is still abundant opportunity for betterment. In one collision, due to improper flagging, which caused 14 deaths and 294 injuries, the flagman at fault had been employed only 24 days and was entirely without previous railroad experience. He had not been examined on the rules, and apparently no effort had been made to ascertain his fitness to perform the duties imposed upon him. When men of such little experience are employed as flagmen, and are permitted to work without any examination to determine their knowledge of the rules, it is unreasonable to assume that they will properly perform their duties, and accidents due to improper flagging may be expected to occur.

The record of accidents investigated shows a considerable decrease in the number of collisions due to the failure of enginemen to obey the indications of block signals. There were but 2 collisions of this nature during the past year, as against 7 the previous year. The 2 collisions herein noted occurred in connection with the movement of high-speed passenger trains on a road equipped with the most modern system of automatic block signals. The enginemen at fault were trusted employees of long experience, one of whom was killed in the collision resulting from his mistake. As previously noted, no adequate explanation can be given for these lapses from duty by trusted and competent men, who in many cases suffer death as a consequence of their error. It is to be hoped that the investigations authorized by the Congress, mentioned in another part of this report, may lead to the development and use of some system of automatic train control to be used in connection with existing systems which will eliminate this class of accidents.

The inherent weakness of the train-order system continues to manifest itself as a prominent feature of the accident record. In 13 of the 40 collisions investigated it appeared that 7 were caused by trains encroaching upon the time of superior class trains and 6 were caused by the failure of trainmen to obey orders. In these 13 collisions 26 persons were killed and 179 injured. Danger of collisions under the train-order system is often increased by the failure of railroad operating officers to employ safeguards provided for by the rules. On most roads where the train-order system is used the rules require that an order establishing a meeting point for opposing trains shall be sent simultaneously to all the trains involved, and also, whenever practicable, to the operator at the designated meeting point, thus providing a check against the possibility of trainmen forgetting or misunderstanding the order. This check, provided by the so-called "middle order," is an important element of safety in the movement of trains on single-track lines, but on some roads the rule which requires it to be used is not observed. Two of the collisions herein discussed, causing the death of 5 persons and the injury of 3, could have been prevented by an observance of the rule, and in both cases the placing of a middle order was practicable. Investigation developed the fact that on one of the roads the rule was observed only when passenger trains were involved, and that on the other road it was not observed at all and had not been enforced for several years previous to this collision, although it had never been rescinded.

Improvement is to be noted in the matter of inspection and supervision of the work of train service employees. On many roads where scant attention formerly was paid to such matters efforts are now being made to insure that employees are familiar with their duties and competent to perform them, and strict obedience to rules is being insisted upon. This improvement is largely due to the work of safety committees in bringing employees and operating officers closer together and inducing them to co-operate for the attainment of safe operating conditions. Such work can not be too highly commended. When conducted along lines calculated to inspire confidence in the minds of employees it can not fail to awaken their enthusiasm and command their earnest support, thus insuring a decrease in the number of avoidable accidents.

Attention is again directed to the need of legislation requiring the standardization of operating rules. That uniformity in rules which is necessary to safety can only be secured by the compulsion of Federal legislation. The efforts of the American Railway Association to standardize operating rules, while commendable, have not been wholly effective, for the reason that the association has no power to compel individual roads to observe its recommendations. The situation is similar to that which led to the passage of Federal legislation enforcing uniformity in the application of safety appliances to cars and engines. With proper rules and operating practices, uniformly applied and enforced on all interstate roads, a decrease in railway accidents may be expected.

In previous annual reports the Commission has called attention to bad conditions of track and roadway which are responsible for many derailments. No material improvement in such conditions during the period covered by this report is noticeable. Six of the 23 derailments investigated were either directly caused or greatly contributed to by bad track. These six derailments were responsible for 33 deaths and 492 injuries, while in all derailments investigated 61 persons were killed and 972 injured. It thus appears that in the derailments investigated bad track conditions were responsible for 54 per cent of the deaths and more than 50 per cent of the injuries due to such derailments from all causes. In at least three of these derailments, occurring in widely separated sections of the country, the track conditions were absolutely unsafe for the operation of trains at speed, and it did not appear that on the roads involved any proper system of track inspection was maintained, or that adequate facilities, in the way of material and labor, for keeping track and roadway in good condition were furnished.

Attention is again called to the lack of definite information respecting track and rail conditions under the increased wheel loads due to the use of heavier locomotives and cars and higher rates of speed. Investigations of accidents caused by broken rails and fractured car wheels have confirmed the need for further investigation to determine with accuracy the stresses to which rails, car wheels, and track structures are subjected under existing conditions of service, and to establish safe working limits for their use.

The Commission renews the recommendation contained in its last annual report respecting legislation requiring the use of steel cars. Experience has demonstrated that steel cars are superior to wooden cars from the standpoint of safety, and the use of wooden cars in front of or between steel cars in high-speed trains should be prohibited.

INVESTIGATION OF SAFETY DEVICES.

Under the provisions of the appropriation act of October 22, 1913, the Commission was authorized and directed to investigate and report regarding the use and necessity of block signal systems, appliances for the automatic control of railway trains and any devices intended to promote the safety of railway operation, and under certain conditions to conduct experimental tests. In December, 1913, the Commission assigned to its division of safety the duty of carrying out these directions of law, and for the purpose of conducting the necessary investigations an engineer-physicist and a signal engineer were employed; other employees of the Commission were also assigned to this work, the organization for carrying on these investigations being completed in February, 1914.

A circular dated December 10, 1913, setting forth the procedure necessary to be followed in submitting devices and systems for consideration, was prepared and distributed. At the time this work was taken up the plans of many devices and systems intended to promote the safety of railway operation which had been presented for consideration were already in the files of the Commission, and since then plans of a considerable number of other devices have been submitted. Detailed information regarding the examination of these appliances is contained in the separately published report of the chief of the division of safety.

Information has been received regarding experiments with train-control devices on several railroads, and in some instances official tests have been made. Within the past year the American Railway Association has adopted certain definitions and requisites for installation of automatic train-control systems and has specified certain adjuncts which may be used in connection with such systems.

A tabulation of statistics pertaining to block signals, interlocking plants, and the telegraph and the telephone for transmission of train orders as issued on the railroads in the United States was published by the Commission under date of January 1, 1914. As shown therein, the total length of railroad line operated under the block system at that time was 86,736.9 miles. The increase during the year 1913 was 2,787.1 miles.

In previous reports the Commission has recommended that railroads be required to adopt the block system.

GRAY-THURBER AUTOMATIC STOP.

To the Commission: JULY 20, 1914.

Under authority conferred upon the Commission by a provision of the urgent deficiencies act approved October 22, 1913, this division has conducted a test of the device of the Automatic Train Control & Signal Co., Pittsburgh, Pa., as installed on the Pennsylvania lines west of Pittsburgh, and I have the honor to submit a report covering this test.

This report has been compiled in accordance with the following outline:

I. Device tested.
II. History of development.
III. Description of installation.
IV. Detail description of apparatus:
  (*a*) Track apparatus.
  (*b*) Engine apparatus.
V. Description of tests.
VI. Analysis of tests.
VII. Discussion.
VIII. Conclusions.
IX. Revised apparatus.

DEVICE TESTED.

This device is known as the Gray-Thurber automatic train-control system and consists of an automatic train stop of the type which employs an insulated portion of the train and a short insulated track section.

HISTORY OF DEVELOPMENT.

This device is a development of the system originally known as the Holtmann system.

The first installation of this system was made on the Pennsylvania lines west, between Allegheny and Jacks Run, Pa., in the winter of 1904–5; it remained in service six or seven months, the apparatus being taken out in September, 1905, when the grades in this territory were changed. As a result of the tests of that installation, certain revisions of the apparatus were made, and after the Block Signal and Train Control Board was organized plans of the revised apparatus were submitted to that body. Several additional changes in the apparatus were made, and on November 27, 1909, the board gave its approval for official tests of the system as it had then been developed.

An installation for purposes of demonstration and test was made during the fall of 1911 on the Pennsylvania lines west, between Bellevue, Pa., and Glenfield, Pa. Preliminary trials were made in October, 1911, but the installation was not completed until early in December, 1911. During that month the Gray-Thurber Co. conducted a series of tests, and in January, 1912, the Pennsylvania Co. conducted further tests. Changes in the apparatus were found to be necessary, and after these were made the installation, on June 3, 1912, was turned over to the Block Signal and Train Control Board for test.

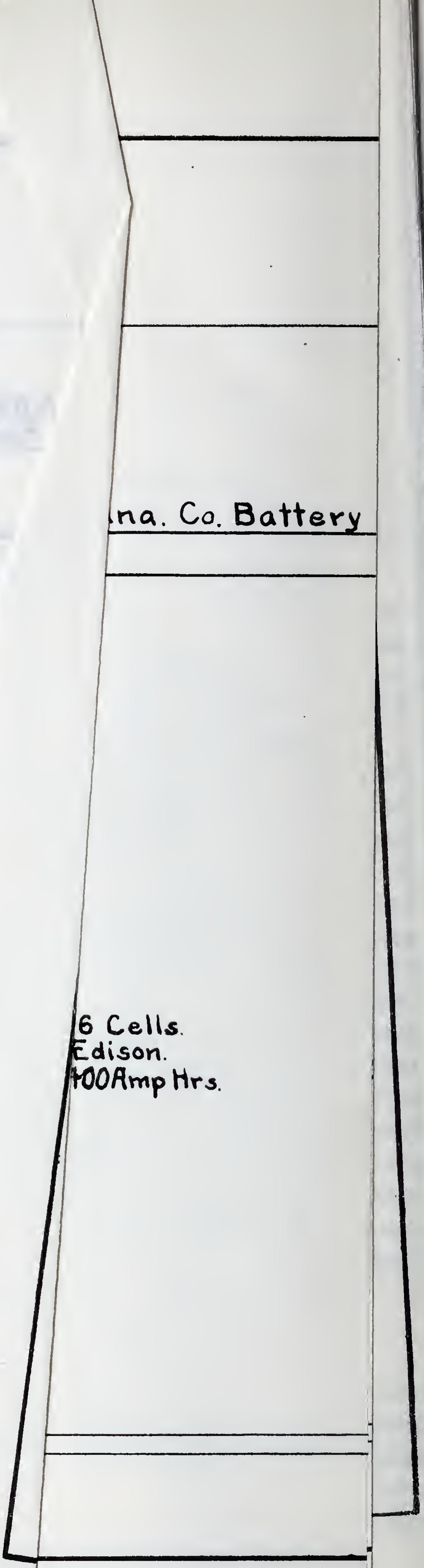
Official tests of this installation were made under the direction of the board during the month of June, but the board was then abolished and the tests not having been completed, were carried on under the direction of the Commission during a part of the months of July and December, 1912.

A report covering the tests which had been made was transmitted to the Gray-Thurber company under date of January 18, 1913; to meet certain points which were raised in this report, revised plans and tabulated data compiled as the result of a further series of experimental tests conducted by the Gray-Thurber company were subsequently submitted. A report covering these plans and data was transmitted to the Gray-Thurber company under date of July 3, 1913, and after the passage of the act of October 22, 1913, directing the Commission to resume the investigation of devices of this character, a request was made by the Gray-Thurber company that the Commission conduct further tests of this system, the installation on the Pennsylvania Lines West having been revised in accordance with the latest plans which had theretofore been submitted. On February 12, 1914, the Gray-Thurber company was notified that further tests would be made, and on April 4, 1914, arrangements with the Pennsylvania Co. for carrying on these tests were completed.

DESCRIPTION OF INSTALLATION.

The installation tested was made on track No. 1, the west-bound passenger track of the four-track line of the eastern division, Pennsylvania Lines West of Pittsburgh, between Bellevue, Pa., and Glenfield, Pa. On this road automatic block signals of the three-position, lower quadrant type, installed with a full block overlap, are used.

Fig. 1.—Track wiring.


na. Co. Battery
6 Cells.
Edison.
400Amp Hrs.

The installation of the Gray-Thurber device comprises equipment at six signal locations, namely, signal bridges 50, 58, 60, 74, 82, and 90, approximately eight-tenths of a mile apart. The track and roadside equipment at each location consists of a short insulated section of track rails at the entrance to the block, and batteries, relays, and wiring which will be described in detail later.

One locomotive equipped with the Gray-Thurber apparatus was used in this test. This locomotive is of the class E–2, Atlantic type, the tender having a steel frame. The engine equipment comprises the insulation of both tender trucks from other parts of the locomotive and train, as well as batteries, a relay, valve, keys, and switches, a speedometer, and switch controlled thereby, together with wiring and piping, all of which will be described in detail later.

During these tests this locomotive was assigned to suburban service between Pittsburgh and Beaver Falls, Pa., making two round trips daily.

DETAIL DESCRIPTION OF APPARATUS.

Track apparatus.—The track and roadside apparatus of the installation tested is illustrated diagrammatically in figure 1. As will be noted from an examination of this plan, the equipment at the signal bridges is identical, except that at bridge 50 one battery and one relay are omitted, this being the first signal location within the territory covered by this installation, and at bridge 90 relay J is energized from the line battery at that point and is controlled by a relay of the railroad company's signal system.

When this installation was made there was an understanding between the Pennsylvania Co. and the Automatic Train Control & Signal Co. that the block-signal system must not be interfered with; and for that reason the Gray-Thurber system was not installed as an adjunct to the block-signal system, but was installed in parallel therewith and controlled by the railroad company's track relays. In order to include the short insulated-track sections in the track circuits controlling the signals, however, the railroad company's track relays H are controlled by the short-section track relays G.

Referring to figure 1, relay H is the railroad company's track relay, which is controlled in the usual manner, except as noted in the preceding paragraph, by the track battery at the west or leaving end of the block section.

The short insulated track section at the entrance of each block consists of two 33-foot rails on one side and one and one-half 33-foot rails on the other side, the two insulated joints at the east end of the short-track section being directly opposite and the other two being staggered, as shown. This track section is sufficiently long to permit the engine, exclusive of tender, to stand between the insulated joints.

Relay G is a 12-ohm track relay for the short insulated section; it is controlled by the short-section track battery, the circuit being from one side of the battery through wire 15, the rail, wire 20, coils of relay G, wire 19, the opposite rail, wire 16, to the opposite side of the battery.

As before noted, relay G controls relay H, one side of the track circuit being broken through G relay points by means of wires 18 and 28. Relay G also controls a detector circuit which energizes detector relay F.

Relay F is a 30-ohm polarized relay; it is normally energized from a detector battery consisting of seven cells of Columbia track battery, the circuit being from one side of the battery, through wire 25, an 8-ohm resistance coil, point of relay G, wire 38, wire 37–22, coils of relay F, wire 42, point of relay J, wire 9, to opposite side of battery. In case relay J is open, the circuit is completed through back contacts of relay J in series. With relay J open, current also flows from the detector battery, through wire 25, resistance coil, G relay point, wire 38, wire 22, to the track rail, and thence by parallel paths through one insulated joint, short-section rails and track battery, to wire 20; and through the long-section track battery, the other insulated joint, to wire 20; then by wire 3 and back point of relay J to the opposite side of the battery. The value of this current depends, of course, upon the resistance of these paths; if, however, the resistance of the insulated joints decreases, the value of the current flowing through these paths increases, and when it becomes great enough, sufficient current will not flow through the coils of relay F to energize it and its points will open. The functions of relay F are to indicate the proper operation of the apparatus, to detect a broken-down insulated joint, and to control the circuit leading to relay J at the signal in the rear. Relay F is made polarized and the line circuit carried through a polarized point to insure that the detector battery is in proper relation to the track. To insure that neither the battery nor the coil wires of the relay could be reversed, and in that way close the polarized points, a special terminal is placed on one coil.

Relay L is a 1,000-ohm relay which is normally energized from a line battery consisting of 16 cells of Edison primary battery, the circuit being from one side of line battery, through wire 66, coils of relay L, wire 29, point of relay H, wire 30, to the other side of battery. The functions of relay L are to repeat the position of track relay H and also to control the circuit leading to relay J at the signal in the rear.

Relay J is a 1,000-ohm line relay and is energized from the line battery at the signal location in advance, the circuit being from one side of battery, through wire 30, line wire 1, wire 4, coils of relay J, wire 5, line wire 12, point of relay L, wire 43, neutral and polarized points of relay F, wire 66, to the other side of battery. Relay J controls a loop around the opposite insulated joints at the entrance to the block section, this loop consisting of wires 22 and 37, point of relay J, wire 3 and wire 20, the loop being broken by the opening of relay J. At all bridges except bridge 90 relay J is made slow releasing, so that it will not open when relay F at the bridge in advance is opening and closing at the time relay J at that location is dropping and picking up. At bridge 90 it was unnecessary to provide this feature, there being no relay F in advance.

At all bridges except bridge 90 the resistance shown in series with wire 25 and point of relay G is in the form of a coil mounted in the relay box; at bridge 90 this resistance coil is contained within the relay itself.

In normal operation when a train passes a signal location the first pair of wheels entering the short track section shunts the short-section track battery, deenergizing relay G. The falling of the armature of relay G breaks the detector circuit controlling relay F and also breaks the circuit through relay H, and the opening of relay H breaks the circuit through relay L; the opening of either relay F or relay L breaks the circuit leading to relay J at the signal location in the rear. When the train passes out of the short-track section, relay G is again energized by the short-section track battery, and the picking up of its armature again closes the circuit for relay F. Relays H and L, and relay J at the signal in the rear, however, remain deenergized until the train has passed into the next block section; then relay H is energized by the long-section track battery, and the picking up of its armature completes the circuit for relay L, which in turn closes the circuit for relay J at the signal location in he rear.

In case of a broken-down insulated joint which permits a large amount of current to flow through multiple paths around relay F, his relay will be deprived of sufficient current to energize it and its points will not be closed, thereby holding open the circuit leading to elay J at the signal in the rear.

Engine apparatus.—The engine apparatus is illustrated diagrammatically in figure 2.

The insulation between the tender and its trucks is made up of two heets of fiber, with a metal detector plate between them. This etector plate is included in the engine relay circuit in such a manner hat broken-down insulation or leakage of current through the insuation will shunt the engine relay, causing it to open. The side-earing plates, the chain hangers, and the rear drawbar of the tender re insulated in the same manner, and all the bolts are included in this detector circuit. The truck insulation and the drawbar insulation are illustrated in figures 3 and 4. A strain insulator, taking the place of the clevis in the brake rigging, is used on the brake rod; and a ball insulator used in the uncoupling chain on the rear of the tender is illustrated in the photograph, figure 5.

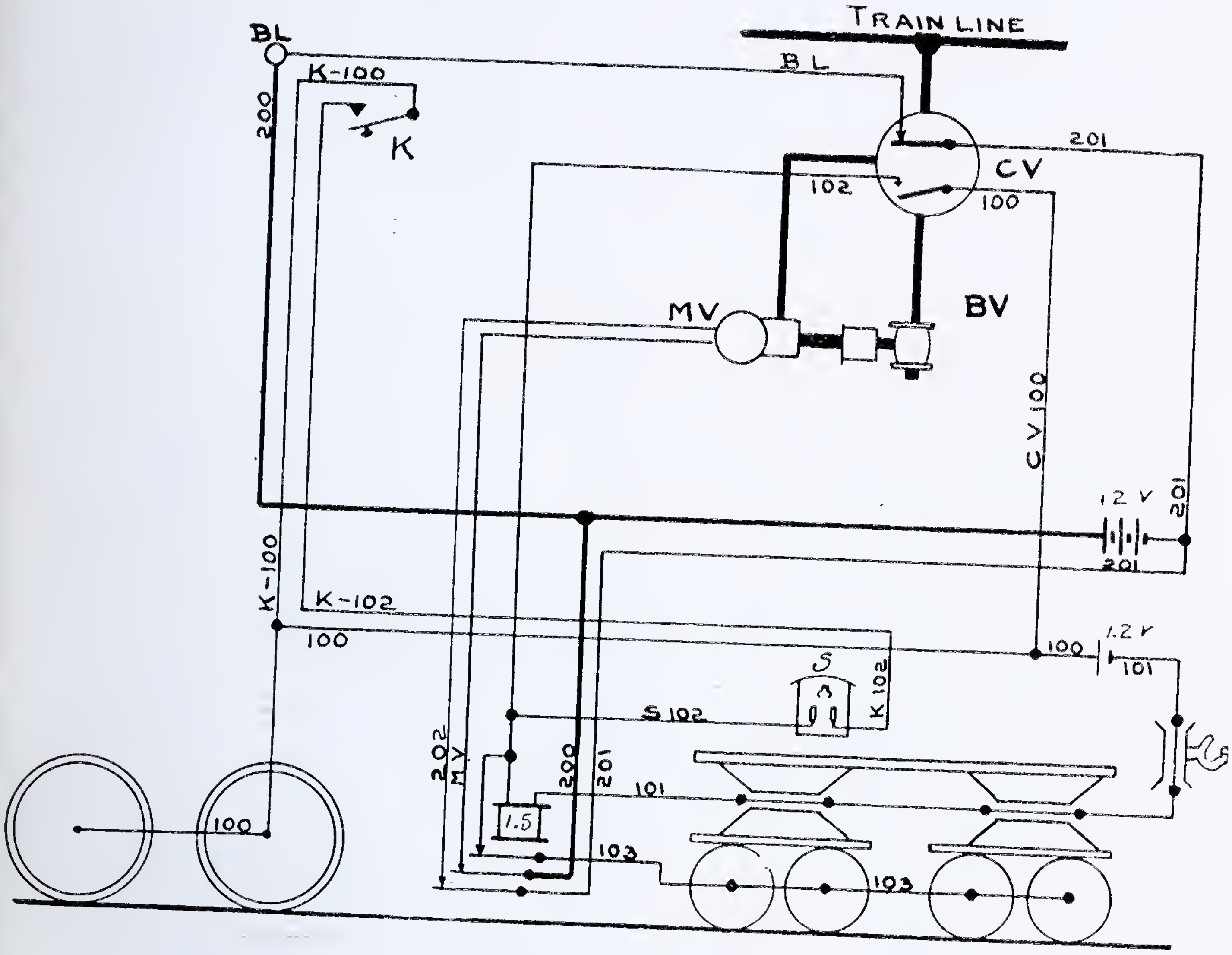
As shown in figure 2, there are two sets of electrical circuits, the first or primary circuits having as a source of energy an Edison storage battery with a potential of 1.2 volts, and the secondary circuit having as a source of energy six cells of Gould storage battery, connected in series, with a potential of 12 volts. Both batteries are of 150 ampere-hour capacity.

With the apparatus in normal condition, current flows in the primary circuit from battery, through wire 101, the detector plates, relay coils, which have a resistance of 1.5 ohms, through a point of this relay, wire 103, the tender wheels, the track rails, the engine drivers and frame, wire 100, to the opposite side of the battery. Wire K–100 leads from wire 100 to pick-up key K, located in the locomotive cab, and wire K–102 leads from the other side of the key to the speedometer contacts, the circuit to the relay being completed through wire S–102 and wire 102. From wire 100, also, wire CV–10 leads to one terminal of cut-out valve CV, wire 102 running from another terminal of the cut-out valve to the engine relay.

In the secondary circuit current flows from one side of battery, through wire 201, point of engine relay, wire 202, coils of magnet valve MV, wire MV, another point of engine relay, wire 200, t opposite side of battery; and through the other branch of wire 201 point of cut-out valve CV, wire BL, electric lamp BL, wire 200, t opposite side of battery.

The cut-out valve CV is operated manually and is accessible onl from the ground. It consists of a two-way cock with two sets of electrical contacts, as shown in figure 2 and figure 6. When in norma running position, the cut-out valve permits the free passage of ai from the train line to the magnet valve MV and to the brake valv BV; and when in this position it also closes one set of electrical contacts, completing the circuit to the blue light in the cab. Whe the cut-out valve is closed, it shuts off all air from the magnet valv and the brake valve, and both electrical contacts are open. When th cut-out valve is in mid position it closes the contacts between wire 100 and 102; a spiral spring prevents the valve from remaining i this position and forces it to the normal running position.

The magnet-valve MV is a common electropneumatic valve which when energized, holds closed an exhaust port and holds open a por allowing air to flow into the piston chamber of the brake valve. Thi arrangement is shown in figure 6.



BL.	INDICATES AUTOMATIC CONTROL IS IN SERVICE BY BLUE LIGHT
B.V.	BRAKE VALVE
C.V.	CUT OUT AND RELEASE VALVE
M.V.	MAGNET VALVE
S.	SPEEDOMETER, PREVENTS STOPPING TRAIN BY TRAIN CONTROL BELOW 10 MILES PER HR.
K	ENGINEER'S KEY.

FIG 2—ENGINE WIRING.

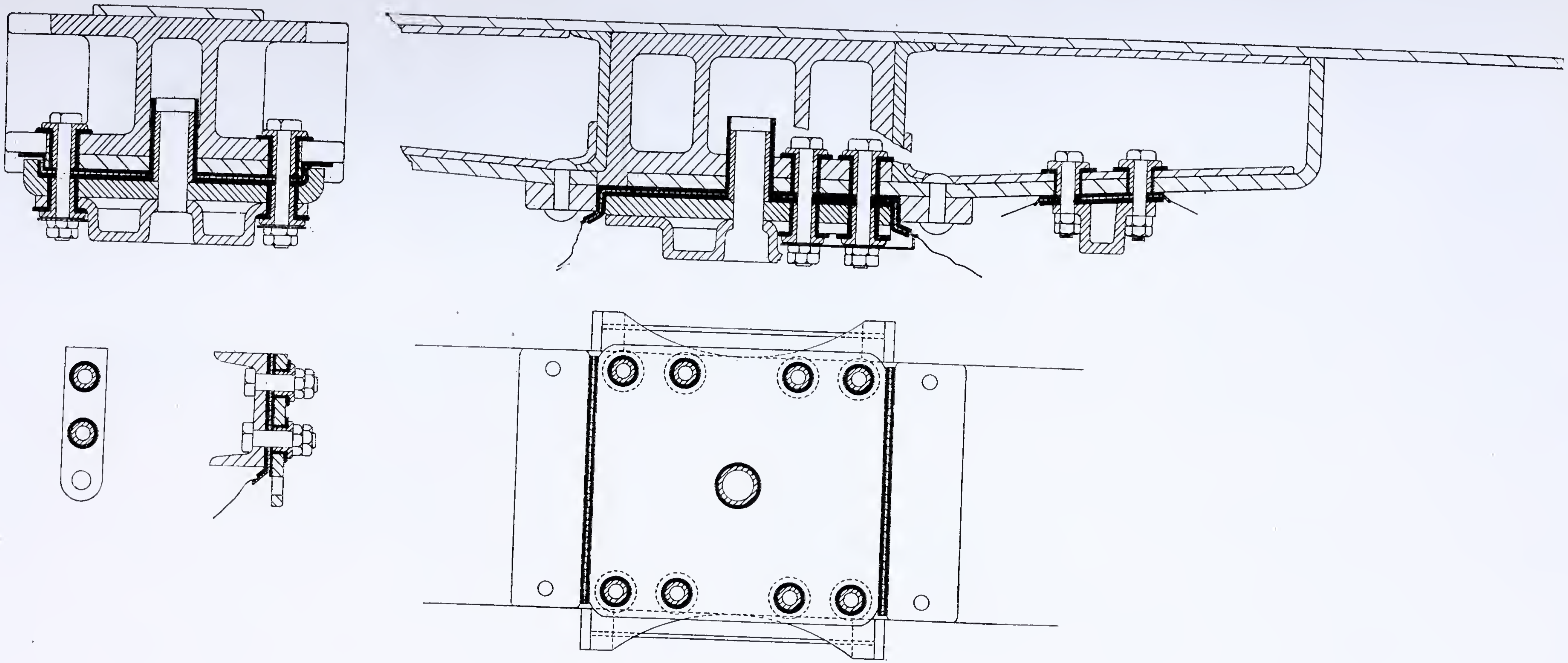


FIG. 3.—INSULATION FOR BODY BOLSTER, TENDER TRUCK.

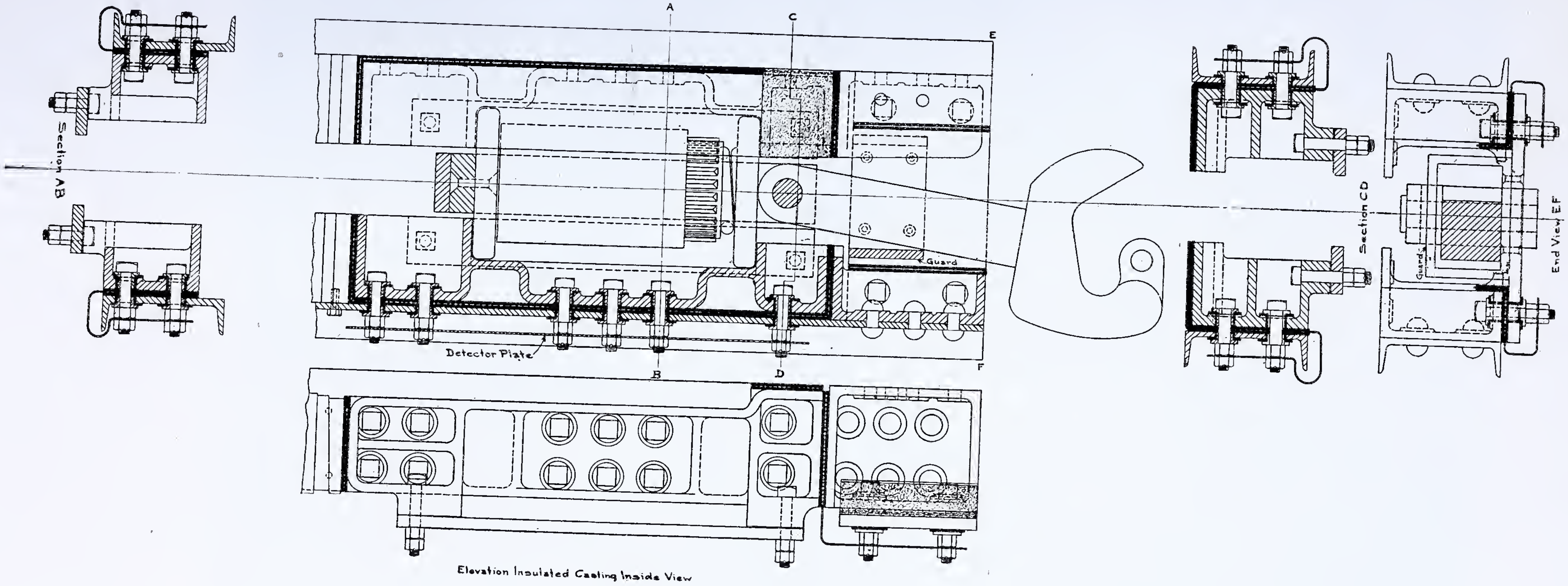


FIG. 4.—INSULATION FOR DRAWBAR.

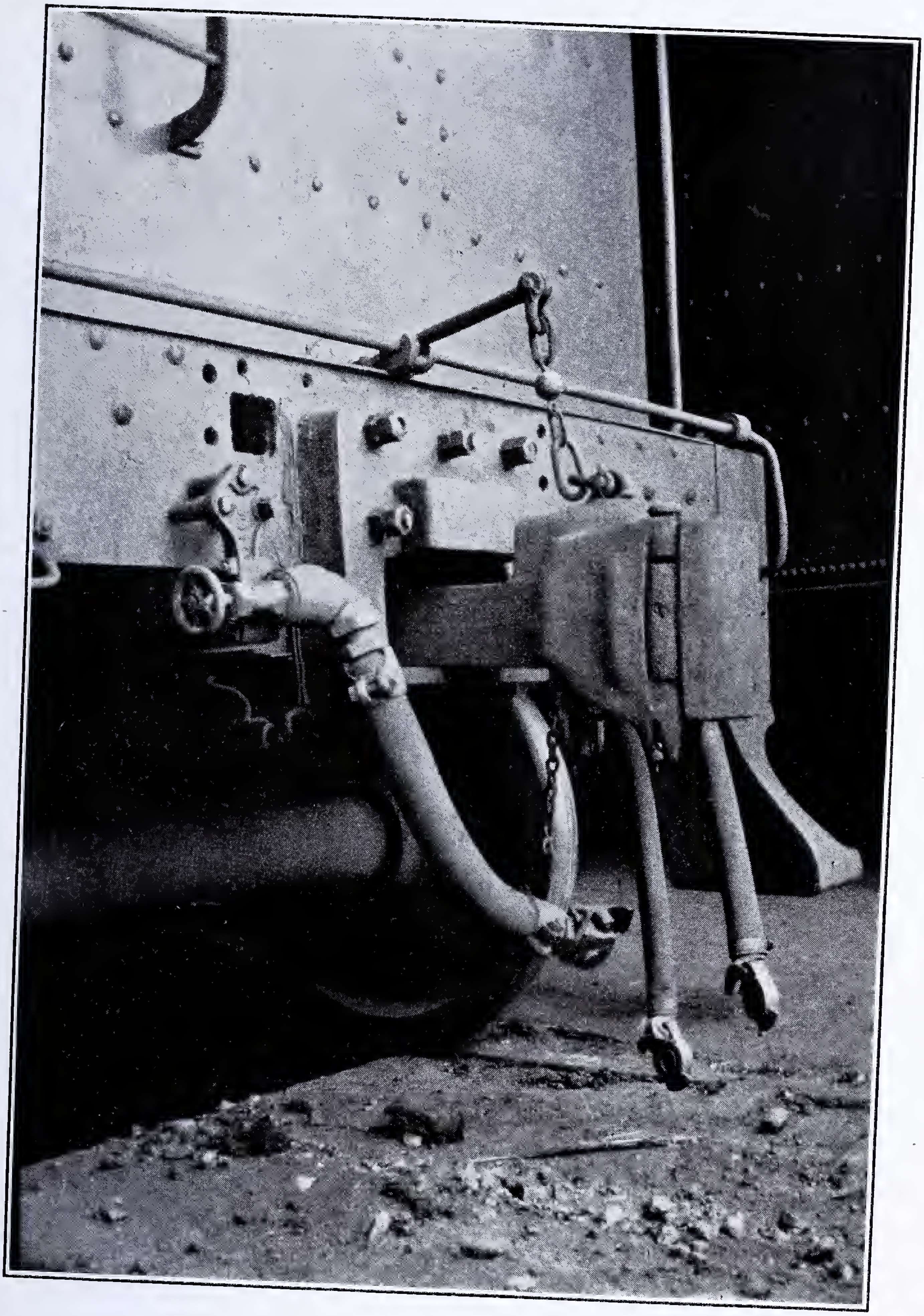


FIG. 5.—INSULATION IN UNCOUPLING CHAIN.

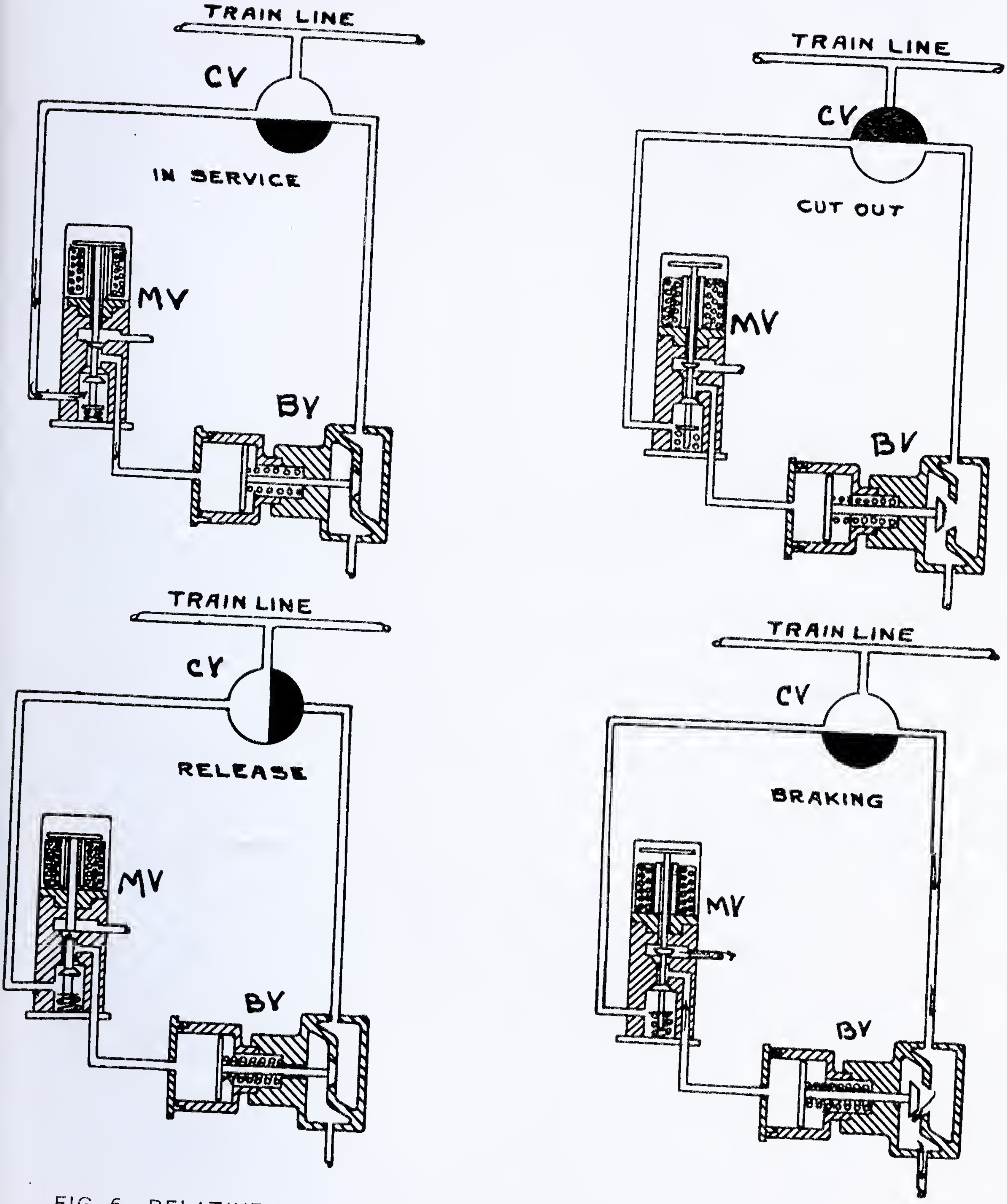


FIG. 6.—RELATIVE POSITIONS OF MAGNET VALVE AND BRAKE VALVE TO CUT-OUT VALVE.

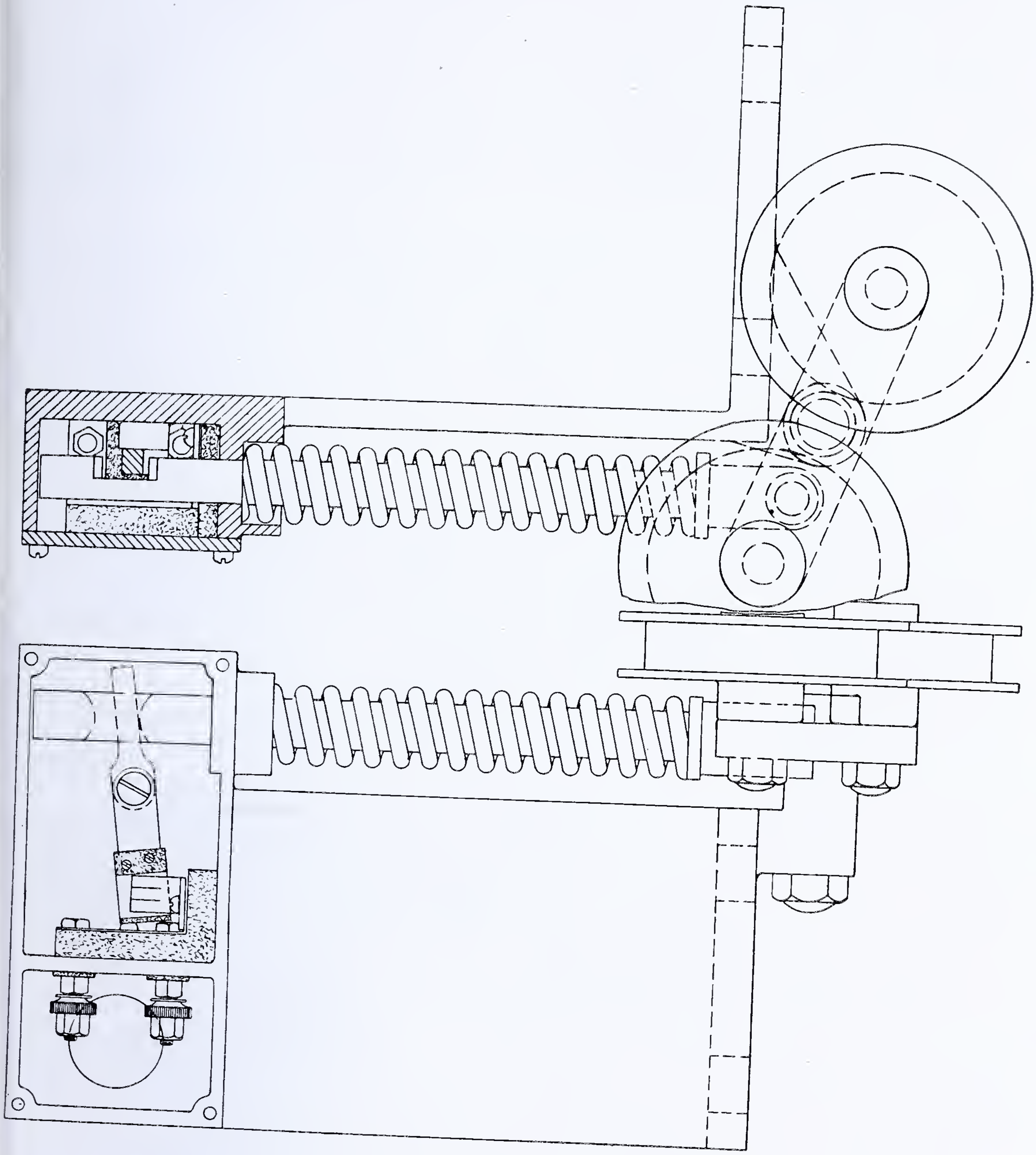


FIG. 7.—BELT DETECTOR FOR SPEEDOMETER.

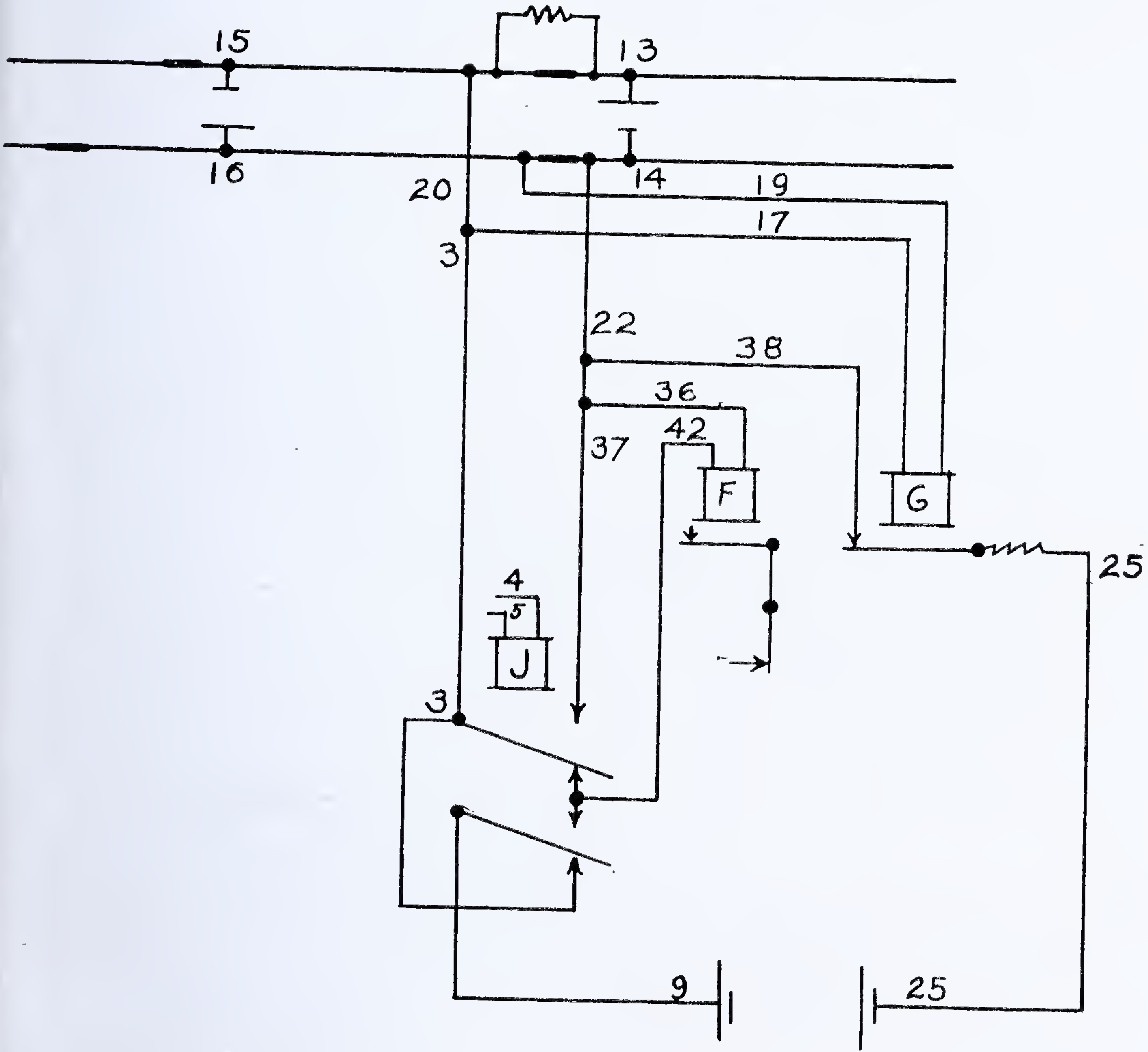


FIG. 8.—TEST CONDITION; PARTIALLY BROKEN-DOWN INSULATED JOINT.

The brake valve is a piston-operated globe valve, the construction being illustrated diagrammatically in figure 6.

When the magnet valve is deenergized, the port leading to the piston chamber of the brake valve is closed by air and spring pressure, and at the same time an exhaust port is opened, allowing air to escape from the brake valve cylinder; when this pressure is removed, the train line pressure unseats the brake valve, opening an exhaust port to the atmosphere. The exhaust port employed to provide a full service application of the brakes is three-eighths of an inch in diameter.

The speedometer is of the Boyer oil-pump type; electrical contacts are attached to the crosshead in such a manner that with a speed of approximately 15 miles per hour or over the contact between wires S–102 and K–102 is opened. A set of roller-bearing idler pulleys is mounted below the speedometer and so connected to a knife switch that if the belt breaks or is removed the switch is automatically opened by the dropping of the idlers, making it impossible under these conditions for the speedometer to close the circuit between wires S–102 and K–102. This arrangement is illustrated in figure 7.

The pick-up key in the engine cab is a common strap key, and the small blue electric lamp is placed in the cab to indicate to the engineman when the cut-out valve is in running position and the train-control apparatus is in service. The speedometer and belt detector switch are located on the pilot beam of the locomotive. All other engine apparatus described is located on the tender, the batteries, relay, and valves being carried in boxes or cases attached to the frame beneath the tender floor.

In operation, when the cut-out valve is unlatched, the spiral spring forces it to the running position, but before it reaches that position it momentarily closes the contact between wires 100 and 102. When this contact is made, the relay is energized, current flowing from one side of the battery, through wire 101 and the detector plates, relay coils, wire 102, cut-out valve contact, wire CV–100, wire 100, to opposite side of battery. The relay, being energized, picks up its armature and the normal primary circuit previously described is then completed and holds the relay closed as the cut-out valve completes its movement to running position. When the relay is energized the secondary circuits previously described are also completed, and air from the train line is permitted to flow through the magnet valve into the cylinder of the air-brake valve, seating the latter valve.

The apparatus remains in this condition as long as everything is normal, but when the engine enters a block and the pair of opposite insulated joints comes between the rear engine wheels and the tender wheels the primary circuit on the engine is broken unless the external electrical path provided by the loop and controlled by roadside relay J, previously described, is completed. When this primary circuit is broken the engine relay is deenergized, and this in turn deenergizes the magnet valve, which allows the brake valve to open and the train line pressure to escape to atmosphere, causing an application of the brakes.

There are two methods whereby the apparatus may be restored to normal condition. As the engine relay is of the stick type, it remains deenergized until restored by some path other than the original circuit. After the apparatus has operated and the speed of the train has been reduced sufficiently to close the contacts of the speedometer switch, the relay may be energized by closing the pick-up key K in the locomotive cab, or after the train has been brought to a stop the cut-out valve may be turned until the contact between wires 100 and 102 is closed.

If relay J is closed, however, and the loop around the opposite insulated joints is completed, the engine relay is maintained energized, the primary circuit being completed through this loop instead of directly through the track rails. This circuit is then as follows: From one side of battery, wire 101 and detector plates, coils of engine relay, point of engine relay, wire 103, tender wheels, rail, wire 22, wire 37, point of relay J, wire 3, wire 19, rail, engine wheels and frame, wire 100 to opposite side of battery.

DESCRIPTION OF TESTS.

The details for carrying on the tests of the Gray-Thurber system were arranged with the railroad company on April 9, and on April 10 and 11 the apparatus was examined, and locked and sealed with Government seals. On Monday, April 13, the tests were begun.

The engine apparatus was not in service except during the tests; on other runs it was cut out by means of the cut-out valve, and the speedometer belt was removed. In making a test run, the speedometer belt was put on and the cut-out valve was turned, usually at the station at Allegheny or Pittsburgh, where the train was made up. The apparatus was ordinarily cut out of service and the speedometer belt removed at Glenfield or the first regular station stop beyond that point. Note was made of the condition of the track apparatus and engine apparatus, the rate of speed of the train at each signal location, the operation of the system, and the conditions of weather, rail, and ground, as well as any other conditions affecting the test.

In making these tests the engineman did not disregard the block-signal indications; but to cause a stop operation of the system it was necessary to create some possible condition of the apparatus.

Ordinarily to cause a stop relay J was opened, either by disconnecting one of the wires from the relay coils or by disconnecting one of the line wires or opening relay F at the signal in advance, thereby opening the loop around the opposite insulated joints, which is controlled by the armature of relay J. A number of other conditions were also set up for the purpose of ascertaining what the result would be in actual service should conditions occur similar to those artificially created.

At the beginning of the tests engine 9238, equipped with this apparatus, was assigned to trains 61 and 69. Train 61 was a local train leaving Allegheny at 9 a. m., central time, and making regular stops at nearly all stations within the territory equipped with this system. This train passed the locations equipped with the roadside apparatus at rates of speed varying, approximately, from 6 to 50 miles per hour. Train 69 was a through train leaving Pittsburgh at 4.02 p. m., central time, and making its first regular stop west of Allegheny at Rochester, about 25 miles from Pittsburgh. This train passed the signal locations equipped with this system at rates of speed varying, approximately, from 45 to 69 miles per hour.

On account of alleged delay to following trains, due to stopping train No. 69 for purposes of test, the system was not cut in on train 69 after April 13, tests being made only on train 61 until April 18, when engine 9238 was assigned to trains 63 and 73. Train 63 was a fast train leaving Pittsburgh at 11 a. m., central time; its first regular stop west of Allegheny was at Sewickley, about 12 miles from Pittsburgh. Train 73 was a local leaving Allegheny at 5.15 p. m., central time, and stopping at nearly all stations within the territory equipped with this system. On May 5 a pipe was run from the exhaust port of the air-brake valve to the front end of the tender and a whistle connected thereto; the port in this connection was one-eighth inch in diameter and would not allow sufficient air to escape, with the air pump running, to cause an application of the brakes. Beginning on May 5 and continuing until the conclusion of the tests, this whistle was depended upon to indicate the operation of the engine apparatus, instead of applying the brakes. At the beginning of each run this whistle was tested to insure that the connections were not clogged by scale or rust, or that it was not out of order from other cause. And on May 5 and during the remainder of he tests, except on July 13, engine No. 9238 was assigned to service on trains 61 and 69. On July 13, engine No. 9238 was assigned to pecial service for test purposes.

For convenience, the insulated joints forming the limits of the hort insulated rail section at each location were numbered 1, 2, 3, nd 4, and these numbers were used in compiling the records of the est. Facing in the direction of traffic, the joint in the right-hand rail at the east end of the short section was numbered 1, and the opposite joint in the left-hand rail was numbered 2, the joint in the right-hand rail at the west end of the short section was numbered 3, and the other joint in the left-hand rail was numbered 4.

The following tests of the system were made:

1. All apparatus in normal condition and runs made on both slow and fast trains without causing stop operations.
2. Relays J opened to cause stop operations on both slow and fast trains at each location equipped with this apparatus.
3. Conditions set up equivalent to an intermittently broken-down insulated joint.
4. Special tests to locate trouble in engine apparatus.
5. Conditions set up equivalent to partially broken-down insulated joints.
6. Conditions set up equivalent to making G a slow releasing relay.
7. Short insulated section grounded.
8. Foreign current applied to rails.
9. Contacts 25 and 38 on relay G bridged and detector battery reversed.
10. Sand tests.
11. Wire S–102 grounded on engine frame.
12. Jumper from tender frame to truck of first coach of train.
13. Special tests to measure resistance of primary engine circuit through loop and through ground.
14. Engine running backward in direction of traffic.
15. Engine running head-on against current of traffic.

On the first run after the tests were begun all apparatus was in normal condition, no stop conditions having been set up. For the second run, namely, train 69 on April 13, relay J at bridge 82 was opened, and on the succeeding days until April 23 tests were made by opening J relays at different signal bridges, thus opening the loop or by-pass circuit around the opposite insulated joints at the entrance to block sections; during this period one or more stops of both the high speed and the low speed trains at each signal location were made.

During this period a number of stops were made at bridge 58 with relay J closed. Investigation disclosed the fact that there was some intermittent trouble at this point, causing increased resistance in the by-pass loop. At first this was believed to be in the contact point of relay J and a jumper was placed around this point. This did not cure the trouble, however, and on April 24 wire 22 was disconnected at the relay end and a new wire substituted. This apparently cured the trouble. The old wire was removed on July 14 and it was found that there was a poor connection between the underground wire and the bond wire.

Beginning on April 23, conditions were set up equivalent to an intermittent ground on the short section or an intermittent breakdown in an insulated joint. A wire was connected to the rail on one side of the insulated joint, and the other end of this wire was run to one or more normally open contact points mounted beneath the rail on the other side of the insulated joint, these contacts being intended to be closed when the rail was depressed by a passing train. Similar conditions were set up until April 30, on which date the official tests were discontinued temporarily for the purpose of discovering and correcting trouble with the engine apparatus.

During the special tests between April 30 and May 13 the brake valve was cut out and an ammeter was connected in the primary engine circuit, leads being run from the battery into the first car of the train, and the speedometer belt detector switch was secured in position to maintain the contacts closed. A pick-up key was also arranged in the first car of the train and either this key or the pick-up key in the locomotive cab could be used to pick up the engine relay whenever it opened. The ammeter reading, and later the whistle connected to the exhaust port of the brake valve, indicated when the engine apparatus was operated.

The special tests first conducted indicated that the trouble was of an intermittent character and had the effect either of introducing additional resistance in the primary engine circuit or of providing an additional path around the relay for current in this circuit, so that the engine relay was deprived of sufficient current to keep it energized. After a very few of these special tests had been conducted it was believed that the trouble could be remedied by taking out the primary circuit wiring and installing new wiring and renewing the detector plates if necessary, but it was feared that if this were done the cause of the trouble would not be definitely ascertained. Consequently a series of tests for data was conducted. Different parts of the primary engine circuit were cut out or bridged and trial runs were made until finally the conclusion was reached that the source of trouble was in the front tender truck detector plate insulation.

On Wednesday, May 13, the tender was taken out of service to allow the Gray-Thurber Co. to make a thorough examination and the necessary repairs. The detector plate was removed and a new one substituted. One new sheet of fiber insulation was also put in. The tender was restored to service on Monday, May 18; a trial run was made on train 61 in the morning, and the official tests were resumed on train 69 on the same date. The detector plate which was removed was of copper and had been in service approximately two months. One sheet of fiber insulation was kept wet from a leak in the tank, and apparently the leakage of current across this insulation was sufficient at times to deprive the engine relay of an adequate amount of current to keep it energized. The new detector plate was of galvanized iron, and after it was put in no further trouble of this character was experienced.

On May 18 and 19 tests were made with partially broken-down insulated joints, but on May 20 the locomotive was withdrawn from service for repairs on account of cracks in the engine frame. The official tests were resumed on June 9, tests with partially broken-down insulated joints being made until the conclusion of the official tests on July 14. These tests were made by opening relay J at each location, thus opening the by-pass loop, and also by either placing a connection of known resistance in parallel with the insulated joint to be broken down or by shunting both the short section and the long section in the rear and making a connection of known resistance between these two shunts. The results of these tests are set forth in the analysis following.

On July 3, at bridge 50, a test was made with relay J closed and a jumper across the points of relay G between wires 25 and 38. This was equivalent to making G a slow releasing relay, and it was desired to ascertain whether or not under such conditions the detector battery would have any effect upon the engine relay, this battery opposing the engine battery. No stop indication was received and no effect was apparent, the apparatus operating properly in this test.

On July 3 at bridge 50, a test was also made with the short insulated track section grounded. Relay J was opened and a connection from the short section right-hand rail to ground on a battery chute, with 17.4 ohms in series, was made. This condition is equivalent to a ground of approximately 17.5 ohms resistance on wire 20, and with this condition a stop indication was received on train 69.

On July 6 at bridge 50, a test was made with foreign current applied to the rails. Two cells of Edison storage battery in parallel, having a potential of 1.4 volts, were connected to the rails across insulated joint No. 1, positive west; an ammeter was connected in series with this battery and the total resistance of the ammeter and connections was approximately 0.23 ohm. Relay J was open and relay F would pick up under these conditions, but the polarized contacts were reversed; no stop indication was received on train 61.

On July 7 at bridge 50 another test with foreign current applied to the rails was made. Two cells of Edison storage battery, in series with ammeter and 0.4 ohm resistance, were connected from the east end of No. 1 joint to the west end of No. 3 joint, positive west, and a resistance of 17.3 ohms was connected in parallel with No. 3 joint. Relay J was opened; relay F remained closed and the polarized contacts were not affected, but when opened relay F would not pick up again. With this arrangement a stop indication was received on train 61.

On July 6 a test was made at bridge 50 with relay J open and the detector battery reversed; also a jumper around point of relay G between wires 25 and 38. With this arrangement relay F would pick up, but the polarized contacts were reversed. This condition is equivalent to running the engine backward in the direction of traffic and making G a slow releasing relay. With this condition set up no stop indication was received on train 69.

On July 7 at bridge 66 another test was made with relay J open and the detector battery reversed. With this arrangement relay F would pick up, but the polarized contacts were reversed; a stop indication at this point was received on train 69.

From time to time during the tests sand was applied to the rails under varying conditions of rail, weather, and speed. The results of these tests are set forth in the analysis following.

On July 11, on train 61, tests were made with wire S–102 grounded to the engine frame at the speedometer, and on train 69 on the same date tests were made with a wire connection leading from the tender frame to the front truck of the first coach in the train. With both of these arrangements false clear failures occurred, as noted in the analysis following.

On July 13 engine No. 9238 was assigned to special service for test purposes and three trips westbound and one trip eastbound over track No. 1 equipped with this system were made. On the first trip westbound stops were made with the engine and tender spanning the opposite insulated joints at each signal location, and readings were taken with relays J both open and closed for the purpose of determining the resistance of the primary engine circuit when completed through the loop around the opposite insulated joints and through any other paths which might exist when this loop was opened. Insulated joints were then partially broken down for the following trips. The results of these tests are included in the analysis, together with other tests with partially broken down insulated joints.

For the last eastbound trip with engine 9238 in special service, the battery of the primary engine circuit was reversed and the engine was run backwards, pushing a coach, against the current traffic. For this run relays J at bridges 90, 82, and 74 were open and stop indications were received at these points. All other apparatus was in normal condition and no stop indications were received at other signal ocations. It is noted that the conditions set up for this run are equivalent to running the engine head-on against the current of raffic, or to running the engine backward in the direction of traffic, with the engine apparatus in normal condition.

For the trips on train 69, July 13, and train 61, July 14, the engine battery in the primary engine circuit was left reversed and insulated joints were partially broken down.

On July 14 all apparatus was restored to normal condition and the Government seals and locks were removed.

ANALYSIS OF TESTS.

In making the tests of this system, whenever the train-stop apparatus was cut in service at the beginning of a trip the running of the locomotive past a signal location equipped with the roadside apparatus was considered as one test, and these tests were numbered consecutively. As noted in the foregoing, the official tests were begun on April 13; they were discontinued from April 30 to May 18, during which period special tests to locate trouble with the engine apparatus were conducted; on May 20 the locomotive was taken out of service for repairs on account of cracks in the engine frame; the official tests were resumed on June 9 and were finally concluded on July 14.

The operation of the system was classified and recorded under the following headings:

1. Satisfactory operations.
2. Unsatisfactory operations.
3. Undesirable stops or safe failures.
4. False clear failures at one location only.
5. False clear failures of entire train-stop system.

Satisfactory operations.—If the apparatus was in normal condition and no stop operation occurred, or no stop indication was received, or if relay J was open and a stop operation did occur or a stop indication was received, the operation of the system was considered satisfactory.

Unsatisfactory operations.—If the apparatus was cut in at the beginning of a run, and it became necessary for any reason to cut the apparatus out of service before completing the trip through the territory equipped with this system, the operation of the system was considered not satisfactory at each signal location passed with the engine apparatus cut out of service.

Undesirable stops or safe failures.—A stop operation or a stop indication received at any signal location where the apparatus was, so far as known, in normal condition, and the operation of the engine apparatus at any point other than a signal location equipped with the roadside apparatus, was considered an undesirable stop or a safe failure.

False-clear failures at one location only.—If relay J was open at one signal location and no stop operation occurred or no stop indication was received at that point, and relay F at that point opened or could not be made to hold closed, so that protection was transmitted to the signal location in rear, the operation of the system was considered as a false-clear failure of the apparatus at the one location where relay J was opened; as noted, however, under these conditions protection was transmitted back to the signal location in rear, and an approaching train would be stopped at the signal in rear.

False-clear failures of entire train-stop system.—If relay J was opened and relay F at that point could be made to hold closed, and if no stop operation occurred or stop indication was received either at that point or at the signal location in the rear, that was considered a false-clear failure of the train-stop system.

The total number of official tests of the system which were made was 516. Of this total there were 402 satisfactory operations; 10 unsatisfactory operations; 7 undesirable stops or safe failures at signal locations and 2 more at other points within the territory equipped with this system; also 87 undesirable stops or safe failures at points outside of the territory equipped with this system; 85 false-clear failures of apparatus at one location only, protection being transmitted back to signal in rear; and 12 false-clear failures of the entire train-stop system.

SATISFACTORY OPERATIONS.

In the tests in which the operation of the system was considered satisfactory no stop operations occurred or stop indications were received in 149 cases; stop operations did occur or stop indications were received in 253 cases. In other words, in 149 cases no stop conditions of the ground apparatus were set up, and the engine apparatus was maintained in normal running condition, and in 253 cases stop conditions of the ground apparatus were set up and operations of the engine apparatus resulted.

In a large proportion of these 253 cases the conditions created were not intended merely to cause stop operation, but were designed to determine whether or not under certain local or operating conditions which might arise in actual service the system would operate as intended or would provide adequate protection. In the cases of this character, included within this number of stop operations, the system performed its functions properly, notwithstanding the abnormal conditions which had been created.

UNSATISFACTORY OPERATIONS.

Six unsatisfactory operations occurred on train No. 73 on April 29. For this run the apparatus was cut in at Allegheny; the sand blower was turned on while leaving Federal Street Station yard, and this caused an operation of the apparatus and an application of the brakes. The pick-up key was then held until the train passed out of the yard. Two other operations of the apparatus occurred, causing brake applications, before reaching bridge 50; one of these occurred a short distance east of OC bridge and the other a short distance east of signal bridge 42. The apparatus was cut out of service at this latter point to avoid delay to traffic. The cause of these operations of the apparatus was not apparent at that time, but was later found to be the leakage of current in the primary engine circuit from the front truck center detector plate to ground on the tender frame. In this case and on this account unsatisfactory operations at all bridges, 50 to 90, inclusive, were noted.

On June 13 four unsatisfactory operations on train 69 were noted, at bridges 66, 74, 82, and 90. For this run the apparatus was cut in at Union Station; a leak was noted in the magnet valve and there did not appear to be sufficient current flowing through this magnet coil to hold the valve tightly closed; the lights in the relay box and the engine cab also were dim. A stop indication was received at the signal bridge east of Federal Street station; the operation of the pick-up key failed to cut off the whistle, and the cut-out valve was operated for that purpose at the station stop at Allegheny. A stop indication was also received at bridge 58, and the pick-up key again failing to cut off the air supply from the whistle, the system was cut out by turning a cock in the whistle-pipe connection. Investigation the next day disclosed the fact that the high-voltage engine battery was exhausted.

UNDESIRABLE STOPS OR SAFE FAILURES.

The distance between the bearing point on the rails of the front wheels of the insulated tender trucks and of the rear wheels of the locomotive was approximately 9 feet. If at any location insulated joints were not sufficiently staggered, so that both joints would come between the front tender wheels and the rear locomotive wheels, the primary engine circuit would be broken, and if a sufficient time interval elapsed, the required time interval being very short, the engine relay would open and an application of the brakes would follow. Similar operations would occur in case of two unbonded or poorly bonded joints being opposite one another, or an unbonded or a poorly bonded joint being opposite an insulated joint, which would introduce a sufficient amount of resistance into the primary engine circuit to prevent flow of current in sufficient quantity to maintain the engine relay energized.

Within the territory traversed by locomotive No. 9238 when the apparatus was in service there were several locations where operations of this character occurred. At a signal bridge east of Federal Street Station, Pittsburgh, a pair of insulated joints was staggered only 4 feet 6 inches, and numerous operations of the system occurred at this point. At a dwarf signal a short distance west of Federal Street Station, in the track leading from the station yard, there was a pair of insulated joints staggered 7 feet 6 inches, and there was also an unbonded rail joint almost directly opposite the insulated joint in the right-hand rail. There was also a pair of opposite insulated joints at a highway and street car crossing just east of the station at Rochester. Operations of the system frequently occurred at both of these places. In crossovers between tracks No. 1 and No. 2, which were occasionally used by trains 61 and 69, there were pairs of insulated joints which were not staggered sufficiently to prevent safe failures, and a few operations of the system occurred on these crossovers.

Undesirable stops also occurred in case of high resistance contact between tender wheels and rails, due to the presence of sand, rust, or other nonconductor on the rail. Safe failures due to this cause frequently occurred when sand was used while the train was starting from stations; special sand tests were also made when the train was running at different rates of speed.

On April 17 a full pipe of sand was used when the train was running at approximately 40 miles per hour, and on April 18 the sand blower was turned on for nearly the entire trip with train 73 to keep the engine wheels from slipping. On July 8 sand tests were made by using a full pipe of sand at different times at speeds of approximately 6, 12, 20, 35, and 65 miles per hour. In only one of these special sand tests was a stop indication received, namely, when the speed was approximately 6 miles per hour.

The following tabulation shows the number and location of the undesirable stops which occurred or stop indications which were received during the official tests:

Undesirable stops or safe failures.

Date.	Within territory equipped.							
	At signal bridge No.—						On sand.	
	50	58	66	74	82	90	Number.	Location.
Apr. 14	......	1	......	......	......	......	......	
17	......	1	......	......	......	......	......	
20	......	1	......	......	......	......	......	
21	......	1	......	......	......	......	......	
24	......	1	......	......	......	......	1	Emsworth.
27	......	......	......	1	......	......	......	
28	......	......	......	......	1	......	......	
une 18	......	......	......	......	......	......	1	Ben Avon.
Total	......	5	......	1	1	......	2	

Undesirable stops or safe failures—Continued.

Date.	Outside of territory equipped.						
	Dwarf signal west of Federal Street Station.	Signal bridge east of Federal Street Station.	Opposite joints, crossing at Rochester.	Cross-overs.	On sand.		Other location.
					Number.	Location.	
Apr. 13		1					
14	1						
17					3	Allegheny	
18		1					
20					1	Allegheny	
27					1	do	
29					1	do	6
May 18		1	1	1			
19	1	1	1		1	Woods Run	
June 9		1	1	1	1	Allegheny	
10		1			1	Woods Run	
11		1	1				
13	1	1					
15		1	1				
16	1	1					
17	1	1	1		1	Allegheny	
18	1	1	1	1			
19	1	1	1				
20	1	1	1				
22		1	1				
23		1	1				
25		1	1				
26	1	1					
27		1	1				
29	1	1	1				
30	1	1	1		1	Woods Run	
July 1	1	1	1				
2	1	1	1				
3		1	1				
6		1	1				
7		1	1				
8	1	1	1		1	Economy	
9		1					
10		1					
13					1	Pittsburgh	
14		1					
Total	14	30	21	3	13		6

Grand total, within territory equipped, 9; outside of territory equipped, 87.

As will be noted from the description contained in the first part of this report, the speedometer contacts are designed to be closed when the engine is traveling at a speed of approximately 15 miles per hour or less, and when these contacts are closed the engine relay can be maintained energized by closing the pick-up key contact. In the early tests it was customary to hold the pick-up key closed while the engine was passsing the signal bridge east of Federal Street Station and the dwarf signal west of Federal Street Station, and ordinarily when sand was used. But after the official tests were resumed in May and the whistle indication was used instead of applying the brakes the speedometer belt was not used and the belt detector switch was secured in its upper position so that the speedometer contacts were held closed constantly. The engine relay could then be picked up at any time, regardless of the speed of the train, by means of the pick-up key in the cab, and after this arrangement was put in the pick-up key was not used except to pick up the relay after a stop indication had been received. In some instances also outside of the territory equipped with this system sand was used by request for the purpose of causing an operation of the apparatus to insure that the whistle was in proper working order.

It is apparent, therefore, that had the speedometer been in normal operating condition and had the pick-up key in the cab been used as intended in the official tests from May 18 until the final test on July 14 many of the undesirable stop indications noted during that period would not have been received. The speedometer had been adjusted so as to open its contacts whenever the speed of the engine exceeded approximately 15 miles per hour. No tests were conducted for the purpose of determining whether or not the speedometer contacts were opening at the rate of speed intended, as it was not considered necessary in a test of this character to determine the accuracy or efficiency of a commercial article such as a speedometer.

To avoid undesirable stops or safe failures, such as occurred at the signal bridge east of Federal Street Station, the dwarf signal in the lead to the Federal Street Station yard, the crossovers noted, and the opposite insulated joints at the highway and street car crossing at Rochester, it would be necessary to insure that, within the territory traversed by locomotives equipped with this device with the apparatus cut in service, all insulated joints were properly staggered so that they could not be spanned by the rear locomotive wheels and the front tender wheels, and that all other rail joints were properly bonded.

FALSE-CLEAR FAILURES.

The following is a tabulation of the false clear failures which occurred during the official tests:

Test No.	Date.	Train No.	Signal bridge No.	Ohms resistance in parallel with insulated joint No.—				False-clear failure—	
				1	2	3	4	At one location only.	Of entire system.
99	Apr. 24	73	66	1.8	....	....	....	1	....
124	Apr. 27	73	[1] 74	....	....	....	....	....	1
130	Apr. 28	73	[1] 74	....	....	....	....	....	1
151	May 19	61	50	2.137	....	....	....	1	....
158	May 19	69	58	4.6	....	....	....	1	....
171	June 9	69	66	.1	....	....	....	1	....
173	June 9	69	82	2.55	....	....	....	1	....
175	June 10	61	50	....	1.9	....	....	1	....
177	June 10	61	66	.1	....	....	....	1	....
179	June 10	61	82	2.55	....	....	....	1	....
181	June 10	69	50	....	1.9	....	....	1	....
183	June 10	69	66	....	8.0	....	....	1	....
185	June 10	69	82	....	4.25	....	....	1	....
187	June 11	61	50	....	....	0.03	....	1	....
193	June 11	69	50	....	....	.03	....	1	....
198	June 11	69	90	....	....	1.28	....	1	....
199	June 12	61	50	....	....	.03	....	1	....
201	June 12	61	66	....	....	4.00	....	1	....
205	June 12	69	50	....	....	3.95	....	1	....
206	June 12	69	58	....	....	5.9	....	1	....
207	June 12	69	66	....	....	8.4	....	1	....
208	June 12	69	74	....	....	5.25	....	1	....

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[1] See text.

Test No.	Date.	Train No.	Signal bridge No.	Ohms resistance in parallel with insulated joint No.—				False-clear failure—	
				1	2	3	4	At one location only.	Of entire system.
209	June 12	69	82		4.15			1	
211	June 13	61	50			3.95		1	
213	June 13	61	66			8.4		1	
214	June 13	61	74			5.25		1	
215	June 13	61	82		4.15			1	
217	June 13	69	50			3.95		1	
223	June 15	61	50			3.95		1	
225	June 15	61	66			8.4		1	
227	June 15	61	82			2.0		1	
229	June 15	69	50			3.95		1	
230	June 15	69	58			5.9		1	
231	June 15	69	66			8.4		1	
233	June 15	69	82			2.0		1	
234	June 15	69	90			4.1		1	
235	June 16	61	50			3.95		1	
237	June 16	61	66			8.4		1	
239	June 16	61	82			2.0		1	
241	June 16	69	50			3.95		1	
242	June 16	69	58			5.9		1	
243	June 16	69	66			8.4		1	
244	June 16	69	74			5.25		1	
245	June 16	69	82			2.0		1	
247	June 17	61	50			3.95		1	
249	June 17	61	66			8.4		1	
251	June 17	61	82			2.0		1	
253	June 17	69	50				4.2	1	
254	June 17	69	58				13.8	1	
259	June 18	61	50				4.2	1	
265	June 18	69	50				4.2	1	
278	June 19	69	58				13.8	1	
279	June 19	69	66				10.5	1	
281	June 19	69	82				3.02	1	
283	June 20	61	50	4.26				1	
289	June 20	69	50	4.26				1	
290	June 20	69	58	5.24				1	
291	June 20	69	66	4.72				1	
293	June 20	69	82				3.02	1	
295	June 22	61	50	4.26				1	
296	June 22	61	58	5.24				1	
297	June 22	61	66	4.72				1	
301	June 22	69	50	4.26				1	
302	June 22	69	58	5.24				1	
303	June 22	69	66	4.72				1	
305	June 22	69	82	4.6				1	
307	June 23	61	50	4.26				1	
309	June 23	61	66	4.72				1	
313	June 23	69	50	4.26				1	
314	June 23	69	58	5.24				1	
315	June 23	69	66	4.72				1	
317	June 23	69	82	4.6				1	
319	June 25	61	50		4.13			1	
325	June 25	69	50		4.13			1	
331	June 26	61	50		4.13			1	
337	June 26	69	50		4.13			1	
338	June 26	69	58		6.2			1	
343	June 27	61	50		5.5			1	
349	June 27	69	50		5.5			1	
355	June 29	61	50		5.5			1	
361	June 29	69	50		5.5			1	
385	July 1	69	50	10.0				1	
399	July 2	69	66			19.5		1	
415	July 6	61	[1] 50					1	
421	July 6	69	[1] 50					1	
459	July 9	69	[1] 66					1	
470	July 11	61	[1] 58						1
471	July 11	61	[1] 66						1
472	July 11	61	[1] 74						1
473	July 11	61	[1] 82						1
476	July 11	69	[1] 58						1
477	July 11	69	[1] 66						1
478	July 11	69	[1] 74						1
479	July 11	69	[1] 82						1
501	July 13	69	[1] 66						1
503	July 13	69	[1] 82						1
513	July 14	69	[1] 66					1	
Total								85	12

[1] See text.

Tests Nos. 99, 171, 177, 291, 297, 303, 309, and 315: The track battery for the long section in rear of bridge 66 was not connected as shown in figure 1, but its polarity was reversed. The supervisor of signals stated that the polarity of this battery was reversed from positive on the right-hand rail to positive on the left-hand rail on account of difficulty in keeping the track relay at bridge 58 properly energized, and inasmuch as this change appeared to remedy the trouble this battery had been maintained with its polarity opposite to that of other track batteries in this vicinity. Tests were made at this location with insulated joint No. 1 broken down. On April 24 a shunt was placed around this joint, this shunt consisting of about 25 feet of No. 16 flexible lamp cord, one end being connected to the short section rail and the other end being connected to an iron wire making a loose contact with the rail of the long section in the rear. When relay F was opened it was necessary to insert about two ohms additional resistance in this connection in order to pick the relay up again, but once it was picked up this additional resistance could be cut out, relay F remaining energized. On June 9, 20 inches of No. 18 copper wire, having a resistance approximately 0.1 ohm, was connected in parallel with joint No. 1, and this arrangement was left in place for two runs. On June 20 resistance of 4.72 ohms was placed in parallel with joint No. 1 at this location, this arrangement being left in place for five trips. In all of the eight tests above mentioned false clear failures at this location occurred, and under similar conditions false clear failures of the entire system are possible. Owing to the fact, however, that abnormal conditions of the apparatus at bridge 58, the signal location in the rear, had been created and existed while these tests were made, and therefore the effect upon apparatus at that point, had it been left in normal condition, could not be stated with certainty, the operations in these tests are classed not as false clear failures of the entire system, but as false clear failures of the apparatus at bridge 66 only.

The explanation of this condition is apparently that with the long-section track battery reversed, this battery opposes the detector battery in the circuit leading from detector battery, through wire 25, point of relay G, wire 38, wire 22, rail, wire 14, track battery, wire 13, opposite rail, insulated joint and parellel wire or resistance, wires 20 and 3, point of relay J and wire 9, to battery, as shown in attached print, figure 8. This is equivalent to inserting resistance in the ciruit between wires 38 and 13 and has the effect of increasing the mount of current flowing through the coils of relay F. With this rrangement one battery opposes the other, and the detector battery oes not have the low resistance path that would be provided if the track battery were in series with it. It is therefore apparent that insulated joint No. 1 can be broken down to a greater extent, practically to zero resistance, without depriving relay F of sufficient current to keep it energized.

If the track battery of the short section were reversed, a similar situation would exist with respect to insulated joint No. 2.

In other words, the reversal of the track battery for the long section in the rear decreases the amount of protection afforded by the roadside apparatus against a dangerous condition arising from broken-down insulated joint No. 1, and the reversal of the short section track battery decreases the amount of protection afforded against a dangerous condition arising from broken-down insulated joint No. 2.

As noted in the foregoing, increasing the resistance in the detector circuit between wire 38 and wire 13 or wire 15 decreases the protection afforded against broken-down insulated joints 1 and 2. Furthermore, if the resistance in the circuit between the battery and the coils of relay F were decreased, or if the voltage of the detector battery were increased, a larger amount of the current would flow through the coils of relay F, and consequently the insulated joints could be broken down to a greater extent before relay F would be deprived of sufficient current to keep it energized.

Tests Nos. 124 and 130: On April 27 and 28, at bridge 74, a wire was connected in parallel with insulated joint No. 1, making a positive connection with the rail of the long section in rear, east of No. 1 joint, and leading to normally open loose contacts mounted under the short section rail west of No. 1 joint, these contacts being intended to be closed by depression of the rail under the weight of the train. On April 27 three such contacts were used, and on the 28th only two contacts were used.

The conditions which were created for these tests are equivalent to intermittent trouble with an insulated joint in which contact is made and the insulation entirely broken down only while a train is passing over it, or to an intermittent ground on the short-section rail which is present or of sufficiently low resistance to allow the engine circuit to work through it only when depressed by the weight of a train.

In these two tests the operation is classed as false clear failures of the entire system, and if similar conditions, arising from intermittent trouble of this character, occurred in actual practice, false clear failures of the system would result.

In tests Nos. 151 to 399, inclusive, and tests 459 and 513, contained in this tabulation, insulated joints were partially broken down.

In making these tests ordinarily a wire connection, of known resistance, in parallel with one of the four insulated joints, was made; in some cases this connection was made between shunts across the short section and the long section in rear or diagonally from one short-section rail to the opposite long-section rail. The tabulation shows the amount of resistance in parallel with the insulated joint for each of these tests in which false clear failures occurred, except for tests 459 and 513. In test No. 459 a resistance of 3.06 ohms was connected from the east end of insulated joint No. 2 to a shunt across the short-section rails, and in test No. 513 a resistance of 3.1 ohms was connected from the east end of joint No. 2 to the west end of joint No. 1. Ordinarily the resistance employed was adjusted to the lowest value which would allow relay F to remain energized for an appreciable interval of time. In some cases the time during which relay F remained closed was not noted; in other cases relay F remained closed for periods of from one-half to six minutes and then opened; and in other cases relay F remained closed for periods of from three to seven minutes, the total length of the periods it was watched, and was still closed at the time of departure from that point.

These conditions were created at different times during the day and in many cases were left in place for several days in succession. And during practically all of these tests abnormal conditions for purposes of test were created at all signal locations. It was therefore impossible to state with certainty the condition of relay F at the time the locomotive passed these locations, and whether or not in these cases protection was transmitted to the signal location in rear is not definitely known. For that reason the operations in all of these cases are classed as false-clear failures at one location only If, however, the train should pass the signal location in rear within the time interval after the condition noted had been introduced during which relay F remained closed, a false-clear failure of the entire system would occur; under traffic conditions on the road where this installation was located such occurrences would be quite possible for the reason that during certain parts of the day trains are scheduled with but two minutes headway. But in this connection it should be noted that with conditions of this character, after relay F once opened, it would not again pick up until the abnormal condition was removed, and protection would therefore then be transmitted to the signal location in rear.

The explanation of the operation of the system in false-clear failures due to this cause is as follows:

In normal operation, when the engine passes a signal location with relay J closed, the primary engine circuit is as follows: Battery, wire 101 and detector plates, engine relay coils, and stick point, wire 103, tender wheels, track rails, wire 22, point of relay J, wires 3 and 20, short-section track rails, locomotive wheels and frame, wire 100, to opposite side of battery. The voltage of the battery in this circuit is normally approximately 1.2 volts, and the drop-away point of the engine relay, engine standing, was adjusted at approximately 0.27 ampere. With these values, in order to maintain the engine relay energized, the resistance of the entire circuit must be sufficiently low to permit a current of at least 0.28 ampere to flow through the engine relay coils, the value of this resistance being approximately 4.3 ohms. The resistance of the engine relay coils and engine wiring is approximately 2 ohms, allowing a maximum total resistance of 2.3 ohms in the contacts between wheels and rails and the by-pass circuit around the opposite insulated joints.

It is obvious that if with relay J open any other electrical path existed around the opposite insulated joints, the resistance of which was 2.3 ohms or less, the engine circuit would work through this path and the engine relay would be maintained energized.

Such a path might be provided by any one of the four insulated joints being partially broken down, or by a ground on the short insulated section, or by a combination of these conditions. For example, with insulated joint No. 1 or No. 2 partially broken down, relay J being open, the circuit traced above, instead of following wire 22 to relay J and wires 3 and 20 to the short-section rails, would pass through the broken down insulated joint to the short-section rails and thence through the engine wheels and frame to wire 100 and back to battery. The rails of the long-track sections are practically grounded, and if joint No. 3 or No. 4 were broken down a path would then be provided from the tender wheels through the rails of the long section in rear to ground, to the rails of the long section in advance, through the broken down joint, back to battery as before.

However, as pointed out earlier in this report, if any joint were completely broken down, relay F would be robbed of sufficient current to keep it energized and would open the line circuit leading to relay J at the location in the rear. There is always some leakage of current from the detector battery across the insulated joints through the paths just described. From various readings taken it was found that the long track sections were of very low ground resistance and the short rail sections were of comparatively high resistance. It was also found that the ground resistance was constantly changing. And when a connection of known resistance was placed across a joint, the available path for the return of the engine circuit was composed of a number of parallel paths, the resultant resistance being a variable factor. Under normal conditions the resultant resistance was always too high to permit the primary engine circuit to work through these paths; but if the resistance of one or more of the insulated joints, or of the ground on the short section is decreased, the resultant resistance of the multiple paths described may be low enough to permit the engine circuit to work through them sufficiently to maintain the engine relay energized, and still be high enough to keep relay F energized for an appreciable interval of time, in which case a false clear failure of the system may occur. Furthermore, if the resultant resistance of these multiple paths normally should be high and be decreased sufficiently under the weight of a passing train to a value low enough to permit the primary circuit to work through them and maintain the engine relay energized, false clear failures of the entire train stop system would occur.

It should be noted, however, that except at bridge 66 where the track battery for the long section in the rear was reversed, in none of the tests conducted was an external path around the opposite insulated joints procured of sufficiently low fixed resistance to permit the engine circuit to work through it and at the same time of sufficiently high resistance to allow relay F to pick up after it had been opened. With the conditions set up for test the resistance was either too high to allow the engine circuit to work through it sufficiently to maintain the engine relay energized, or it was low enough so that relay F, when opened due to the passage of a train or other cause, would not pick up again, thereby holding relay J open at the signal location in rear and transmitting protection back to that location.

For test No. 415 at bridge 50, a battery of 1.4 volts potential was connected to the rail, the positive terminal being connected to the rail west of joint No. 1 and the negative terminal being connected to the rail east of joint No. 1. The resistance of the connections was approximately 0.23 ohms. It was the intention to create by this arrangement a condition equivalent to foreign curren flowing east on the rails. With this arrangement no stop indication was received on train 61, but the polarized contacts of relay F were reversed so that the line circuit would be opened, and protection transmitted back to the signal in the rear; in this case, therefore, the operation is classed as a false clear failure of the apparatus at one location only. The engine relay would be energized under this condition, when the opposite insulated joints were spanned by the engine and tender, by the engine battery assisted by the external battery or foreign current.

Test No. 421. For this test, at bridge 50, contacts 25 and 38, relay G, were bridged, and the detector battery was reversed. With this arrangement the engine battery in the primary circuit and the detector battery are in series, and with the point of relay G closed or bridged both of these batteries would tend to hold the engine relay closed, the external circuit being through wires 22 and 38, point of relay G and resistance coil, wire 25, detector battery, wire 9, back contact of relay J, and wires 3 and 20. This condition is equivalent to running the engine backward in the direction of traffic with apparatus in normal condition, except that in this case relay F was reversed and consequently protection would be transmitted back to the signal location in rear; therefore, the operation in this test is classed as a false clear failure of the apparatus at one location only.

For tests 501 and 503 the engine battery was reversed and point of relay G was bridged. This condition is equivalent to running the engine backward in the direction of traffic, with G a slow-releasing relay, and the circuit would be completed as described in connection with test No. 421, except that the current would flow in the opposite direction. In both of these latter cases false clear failures of the train stop system occurred.

Tests Nos. 470, 471, 472, and 473. On July 11, for the run on train No. 61, wire S–102 was grounded on the engine at the speedometer case. With this ground on wire S–102 the engine relay, when opened, picked up immediately. For this trip relay J was open at four bridges, but no stop indications were received. With this condition the circuit for maintaining the engine relay energized would be from battery, through wire 101, and detector plates, relay coils, wire 102, wire S–102, to ground on engine frame, and by wire 100, to opposite side of battery. These tests are classed as false-clear failures of the system.

Tests Nos. 476, 477, 478, and 479. For the trip on train 69 on July 11 a wire was run from the tender frame to the front truck of the first coach in the train. No stop indication was received at the signal bridge east of Federal Street nor at any of the four signal locations where relay J was open. At such locations the circuit for maintaining the engine relay closed would be, with this condition, from battery, wire 101 and detector plates, coils of relay, stick point of relay, wire 103, tender wheels, rails, wheels and truck of coach, wire from truck to tender frame and ground on engine frame, wire 100, to opposite side of battery. These tests are classed as false-clear failures of the system. It is obvious that if similar conditions occurred in actual service false clear failures of the system would follow.

DISCUSSION.

During practically the entire period covered by these tests abnormal conditions of the apparatus were created. These abnormal conditions approximated theoretically possible conditions which might arise in actual service under existing traffic conditions. They were introduced for the purpose of ascertaining whether or not the system would operate properly should such conditions exist. The tests that were made from time to time, in which the apparatus was in normal condition, demonstrated that under normal operating conditions and with the apparatus in normal condition the system will operate as intended.

It is evident from an examination of the plans of this system that dangerous conditions might arise or dangerous failures occur if two or more theoretically possible abnormal conditions were introduced simultaneously. This is also true of many signal and interlocking systems which are operated successfully in daily practice. In view of the fact that these conditions must occur *simultaneously*, however, but few tests under these conditions were made, practically all of the tests being made with only one abnormal condition introduced.

As has been noted, the signals in the territory where this test was made are installed with a full block overlap. The system tested is an automatic train stop which is intended to be used as an adjunct to the block-signal system and does not itself provide any signal indications. In the installation tested the apparatus was arranged to allow the locomotive to pass clear and caution signals without interference, and to stop the locomotive at the first danger signal only; in other words, the apparatus was arranged to operate and apply the brakes a full block away from an occupied block. Should the train then proceed, the next preceding block only being occupied, no stop operation at the entrance to that block would occur.

With this arrangement it is apparent that should a train come out of a siding, the block ahead being occupied, or should certain dangerous conditions arise in a block section after an approaching train had passed the signal in the rear, as, for example, a broken rail, a switch being opened, a car or a train entering the block section from a siding or occupying the siding within the fouling line, or other similar condition, no protection would be afforded by this system.

Protection against dangerous conditions arising from failures or abnormal conditions of the roadside apparatus is intended to be transmitted to the signal location in rear of the point where the trouble exists; this is accomplished by causing a stop condition of the apparatus at the signal in rear to be set up. The train would then be stopped at that location, but if, after being stopped, it then proceeded to the signal location where the trouble existed, no stop operation at that point would occur. The false clear failures at one location only, which are contained in a preceding tabulation, were operations of this character. Furthermore, in case of intermittent or other trouble occurring at one point after an approaching train had passed the signal in rear, such as the breaking down of one or more insulated joints, the presence of a low resistance ground on the short-rail section, or the presence of foreign current of proper polarity and strength, protection would not be provided for that train.

At locations where track batteries were so connected that current flowed in the proper direction, detection of broken-down insulated joints was provided to a high degree. But with the installation of this system it is necessary that some method be employed to insure that current from track batteries will always flow in the proper direction to permit the system to provide protection, as designed against broken-down insulated joints.

A similar condition exists in regard to the primary engine circuit battery, the polarity of which should at all times be opposed to that of the detector batteries, regardless of whether the engine was being operated head-on or backward. In the tests which were made with the engine battery reversed, the conditions which would exist if the locomotive were running backward were duplicated. With this arrangement the detector battery would be in series with the battery in the primary engine circuit, and if relay G were slow-releasing or for any reason held up its armature while the engine and tender were passing the opposite insulated joints at the block entrance the engine relay would be maintained energized regardless of conditions ahead. In other words, with G a slow-releasing relay, if the detector battery and the engine battery were in series the tendency would be to maintain the engine relay energized, and if these batteries were opposed the tendency would be to "kick off" the engine relay. Means should therefore be provided in any installation of this system to insure that under all circumstances and conditions of operation the battery in the primary engine circuit will oppose the detector batteries.

Where this device was installed the direction of traffic was westward only. The normal flow of current in the primary engine circuit through the track rails was westward also; that is, from the tender wheels to the engine wheels. With foreign current in the running rails flowing westward it would have a tendency to keep the polarized contacts of relay F normal, but it would tend to open the engine relay at each indication point. If foreign current were flowing eastward in the running rails it would have a tendency to reverse the polarized contacts of relay F and thereby transmit protection to the signal in the rear, but it would tend to keep the engine relay closed at each indication point.

While in the tests which were made with the engine running against the current of traffic the system operated properly, it should be noted that with the system as installed, in case two trains were started from one point only a short time interval apart, one of them running in the direction of traffic and the other running in the opposite direction, against the current of traffic, the train running against the current of traffic would be stopped when it passed the second signal in rear of the train running with the current of traffic. Furthermore, while the train running against the current of traffic would be protected by the track apparatus ahead, no protection would be provided by the system against a following train; the leading train, when two blocks ahead, would be stopped, and both trains would then be without protection from one another. This would no doubt apply also to other systems of this character.

The operation of the engine apparatus depends upon breaking the primary engine circuit when the opposite insulated joints at the block entrance are spanned by the engine and tender, thus causing the engine relay to open. The operation of the engine apparatus is therefore dependent upon the distance between the front tender wheels and rear locomotive wheels and the speed of the train, which determine the time interval during which the circuit is broken, as well as upon the time required for the relay to open. If the insulated joints at the entrance to the block section were not located directly opposite one another the time interval during which they would be spanned by engine and tender would, of course, be diminished. On the engine equipped and used in this test the distance between the front tender wheels and the rear locomotive wheels was approximately 9 feet; 69 miles per hour was the highest rate of speed recorded in any test; speeds of from 63 to 67 miles per hour were frequently attained. In tests at these rates of speed the relay opened and the apparatus operated properly.

If a ground occurred on wire S–102, regardless of the rate of speed, the resistance of this ground being of less than approximately 2.3 ohms, false-clear failures would occur. In any installation of this system adequate precautions must be taken to insure that this wire will not become grounded, or means must be provided to detect such grounds.

False-clear failures would occur if there were an electrical connection of any sort between the tender frame or body and a steel car or truck in the train behind the tender, provided the resistance of the path thereby provided for the return of current in the engine primary circuit were sufficiently low to allow the flow of a quantity of current adequate to maintain the engine relay energized.

With these two exceptions, all circuits employed in connection with the engine apparatus are properly designed from the standpoint of safety.

The roadside apparatus of this system is similar to apparatus employed in connection with automatic block-signal systems and would not be more difficult to maintain. The storage batteries employed in the engine apparatus could also be kept properly charged by the same facilities as are now generally available for maintaining car-lighting systems. It is proposed by the proprietors to make necessary repairs and renewals of detector plates and insulation when the tenders are overhauled periodically; however, should detector-plate or insulation trouble occur at any time, it would be necessary to withdraw the tender from service until the necessary adjustments or repairs were made. The period of time the tender must be out of service would depend upon the amount of work to be done and the facilities provided for such work. In the one instance of this kind encountered during the tests the tender was out of service from Wednesday morning until the following Monday morning. It should be noted, however, that such a condition does not affect the use of the engine itself nor the use of another tender properly equipped with this system.

CONCLUSIONS.

As a result of the tests which have been conducted the following conclusions have been formulated:

I. The system as installed and tested constitutes a material improvement as compared with other arrangements of the same system previously tested.

II. With the installation of this system the following features must be provided:

1. All insulated joints, except the opposite insulated joints required at the entrance to each block section, must be staggered a distance equal to the longest distance between front tender wheels and rear locomotive wheels of all locomotives equipped; all other rail joints must be properly bonded.

2. Means must be provided to insure that track batteries will not oppose detector batteries, and that the battery in the primary engine circuit will always oppose the detector batteries.

III. The system is deficient in the following respects:

1. The use of sand in starting trains will cause undesirable stops or safe failures of the system unless the pick-up key is held closed.

2. False-clear failures of the system may occur, due to (*a*) a ground on wire S–102; (*b*) bridging the tender drawbar insulation, or an electrical conductor from tender body or frame to car truck or steel car in the train; (*c*) intermittent low resistance ground on short insulated rail section; (*d*) intermittently broken-down insulated joint; (*e*) foreign current in the track rails.

3. Protection against certain dangerous conditions and against failures or defects of apparatus at one point is transmitted to the signal location rear; if these conditions arose or failures or defects occurred after an approaching train had passed the entrance to the block section in rear, protection would not be afforded in time to be of any avail.

The tests conducted have resulted in the accumulation of a large amount of data which should be useful in further development of the system. Such further development, however, can not properly be made by means of experimental tests with only one locomotive and but few locations equipped, and covering but a comparatively short period of time. Properly to develop a system of this character to meet all the needs of actual service it should be installed and used for the purpose intended.

Notwithstanding the defects and deficiencies pointed out in this report, the system in its present state of development, if properly installed and maintained as an adjunct to a block-signal system, would increase the safety of train operation.

REVISED APPARATUS.

During the conduct of the tests and since their completion the proprietors of this system have proposed certain revisions in the apparatus employed. None of these revised arrangements has been thoroughly tried out. Briefly the proposed changes consist essentially of the following:

In order to insure that current from track batteries will always flow in the proper direction to allow the system to provide protection against broken-down insulated joints, all track relays should be polarized. The proprietors also stated that polarized track relays were not employed in this installation for the reason that the railroad company had not used them heretofore in this territory and the understanding when the installation was made was that the existing block-signal system must not be interfered with.

With the installation of this system as an adjunct to an automatic block-signal system, some of the functions performed by relays provided for that particular purpose in the installation tested would be accomplished by utilizing relays of the signal system.

An electropneumatic valve, having relay points attached to its armature, has been designed, the purpose being to combine the functions of engine relay, magnet valve, and brake valve in one instrument and to eliminate one set of engine circuits.

It is intended to locate the speedometer in the box or case on the tender and to include the speedometer frame and metal parts of valves in the detector circuit for the purpose of detecting the grounding of any wire.

The electrical contacts attached to the speedometer are intended to be closed when the rate of speed is between 1 and 15 miles per hour, and at these low speeds the train-control valve is intended to be maintained energized through speedometer contacts for the purpose of obviating undesirable stops due to the use of sand.

Respectfully submitted.

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